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EXPERIMENTAL STATIONS OF PISTON AND GAS TURBINE ENGINES,(U)

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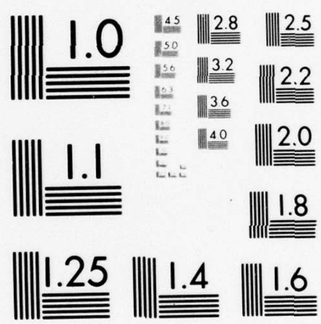
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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

EXPERIMENTAL STATIONS OF PISTON
AND GAS TURBINE ENGINES

By

L. I. Varlamov

FOREIGN TECHNOLOGY DIVISION

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By: L. I. Varlamov

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PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

Page 2.

In the book are examined the questions of organization and equipment of experimental stations and laboratories for conducting the heat engineering tests of the different type of piston internal combustion engines and gas turbine engines.

Besides a selection of the type of testing units and their arrangement/permutation, in the book are given to recommendation regarding the equipment of station by the operating systems, the control devices, measurement and controls. Also are illuminated the questions of noise suppression, industrial sanitation and fire safety.

The book is intended for technical-engineering workers, connected with conducting of the series, plant and experimental tests of the indicated engines.

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PREFACE.

The majestic prospects for the Communist building, marked by the program of KPSS [CPSU - Communist Party of the Soviet Union] on the creation of the technico-material base of communism, provide for the powerful development of all branches of national economy.

For the rearmament of industry, the decisive importance has technical progress in the creation of new technology, technology, organization of production, implementation of overall mechanization and automation of production processes.

In machine-building the production of the internal combustion engines, which possess high efficiency and great possibilities of their wide use in all branches of national economy, acquires special importance.

In the creation of highly efficient internal combustion engines the large role play series and experimental tests.

On the selection of composition, methods and mode/conditions of tests, type of stands, brakes and monitoring-measuring equipment,

depends the quality, engine life and the degree of reliability of the produced engines. These tests make it possible to give the timely, objective estimation of the newly created constructions of engines and to considerably reduce the periods of their finishing and mastery/adoption.

The available Soviet and foreign technical literature, which relates to the region in question, illuminates mainly the procedure of tests and measurements.

In it there are no requirements, presented to experimental stations on organization, equipment and the arrangement/permutation of equipment, the questions of mechanization and automation of production processes, noise abatement, safety, industrial sanitation and fire safety technique.

Is absent also any information on organization and equipment of the laboratories from which in many respects depends the success of tests.

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In this book is made the attempt to generalize and to systematize the available experiment on planning, building, equipment

and the operation of experimental stations and laboratories.

The questions, connected with test equipment, monitoring-measuring equipment, systems of automation and controls, measurement procedure, in the book are not examined, since they are widely illuminated in the available technical literature.

The given in this book units of measurement are given on the effective to 1963 GOSTs.

From 1 January 1963, is introduced the new single international system of units - "SI" (GOST 9867-61) as preferable in all regions of science, national economy and teaching.

If necessary for the conversion of values indicated here, one should use GOST 9867-61.

All observations and responses for the book the request to direct to: Moscow, B-66, 1-st Basmannyy per., 3, Mashgiz.

Page 5.

Chapter 1.

TESTS OF INTERNAL COMBUSTION ENGINES.

§ 1. The purpose and nature of the tests.

1. Designation/purpose of tests.

The experimental stations of the Machine Building Plants, which generate different in construction and designation/purpose piston and gas turbine engines, are intended for conducting the breakings in of rubbing parts, testing, adjustment of these engines and setting conformity to their assigned/prescribed characteristics.

Bench tests of engines is the important concluding stage of the technological process of production in engine construction. In this branch of the machine-building of testing according to their designation/purpose, they are divided into tests of engines in series

production and experimental research tests of experimental production, or to the tests of scientific research character.

In the series production of testing, they are carried out according to programs and commands according to the technical specifications for supply which are develop/processed and are establish/installed conformably for each type of engine.

Tests in series production have as a goal first of all quality control of output. The designation/purpose of these tests is reduced to the following basic tasks:

1) the quality control of the assembly of engine as a whole and of its separate aggregate/units;

2) the breaking in of friction surfaces for an increase in the wear resistance and, consequently, also operational life of engine (for piston engines);

3) testing the established/installed parameters for this type of engine and taking its characteristics in accordance with technical specifications for supply.

Experimental and research tests are usually connected with

experimental production or by the work of design bureaus they are carried out for testing of the new or improved constructions of engines or their separate aggregate/units, units and parts.

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In this case, are carried out comprehensive investigations for research on gas-dynamic processes, work of separate cell/elements and entire construction of engine as a whole.

These tests are carried out also in connection with research on the individual questions of the engine construction: improvement in the power-supply systems, lubrication, cooling, starting/launching, selection of the new types of fuel/propellants, oils, introduction of new technological processes, testing new materials and to other investigations.

All research works are completed by conducting endurance tests and by taking detailed characteristics for the development/detection of the conformity of the designed calculated parameters of engine actual.

2. Types of tests.

During the manufacture of engines in series production, are distinguished the following types of tests:

1) delivery or plant;

2) controls;

3) commission, selective or otherwise - series.

Acceptance test undergoes each factory-built engine of outside dependence on type, construction and its designation/purpose.

Monitoring test is carried out when technological process and technical delivery specifications require the complete or partial sorting/partition of engine after acceptance test. In this case after the sorting/partition of engine, which usually pursues additional control functions, engine undergoes final, monitoring test. This testing depending on type, the construction and the designation/purposes of engine can undergo each programmed engine, or only limited batch.

In the latter case sorting/partition and monitoring test undergoes only one engine from the determined batch, for example, one of the ten, in this case nine remaining engines undergo only acceptance test and, therefore, sorting/partition does not undergo.

In the presence of two tests, the monitoring test is less prolonged, but the concluding inspection/acceptance of engine they conduct according to it with taking of the final characteristics which will be brought in into engine certificate.

Under the condition of limited sorting/partition the quality of an entire batch, they judge by the control engine which passes sorting/partition with the subsequent monitoring test and is the representative of this batch.

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If during tests are detected the large flaw/defects, which cannot be removed on stand, or engine does not give the necessary characteristics, then it is subject to taking from stand and heads:

a) during single testing into defective department/separation for a partial or complete sorting/partition and after the elimination of flaw/defects to the repeated or additional testing:

b) during double tests into assembly department/separation, if were reveal/detected flaw/defects during acceptance test, and into partition department/separation, if they were determined luring monitoring test.

After the elimination of engine defects, again heads for the appropriate (delivery or control) repeated testing, since the previous testing luring which were determined the flaw/defects, usually it is nullified.

The last/latter types of the tests of series production are endurance tests, they bear selective character and they are carried out periodically, after definite intervals of time or with the issue of the determined batch or series [1] of engines.

FOOTNOTE [1]. A series he is called the batch of the one-type engines, differing by the service life and which possess complete interchangeability parts. ENDFOOTNOTE.

Usually these tests are carried out for the target/purpose of

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EXPERIMENTAL STATIONS OF PISTON AND GAS TURBINE ENGINES.

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periodic quality control of engines and its operational data (engine life, wear, etc.) or for the target/purpose of testing changes and improvements, introduced into the construction of engine.

The tests of experimental production and research include the following types of tests, connected with development, finishing and the delivery of new modifications or new specimen/samples of the engines:

1) experimental finishing;

2) state (interdepartmental);

3) research.

Experimental finishing and research tests are usually connected with the work of design bureaus and scientific research organizations and they are carried out for the target/purpose of testing construction and investigation of the individual questions of engine construction.

Official tests are official tests and they are carried out for the target/purpose of the inspection/acceptance of the new or modified specimen/samples of engines.

3. Composition of tests.

Efficiency of all types of piston internal combustion engines very strongly depends on the mode/conditions of the first hours of their work. If we to the newly assembled engine in the beginning of its work give normal load, then in this case will unavoidably follow the premature intensive wear of friction surfaces with the appearance on them of scores. This is explained in the first stages of the operation with the presence of roughnesses - the traces of machining, in consequence of which on friction surfaces appear considerable specific loads.

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Therefore appears the need for the smoothing of these roughnesses for decrease in the specific loads for the friction surfaces for the purpose of an increase in the wear resistance.

Training/preparation of the assembled engine for work on full load is achieved by preliminary processing or its rolling, in process

of which the articulated vapors of engine obtain the possibility of a gradual increase in the load with them mutual breakings in. Therefore for all newly manufactured or assembled after repair engines rolling or breaking in is the first necessary technological operation which is a part of acceptance test.

As show the conducted investigations, complete the breaking in of the parts of engine it is continued the long time, measured of dozen hours. However, this process continues unevenly, since the basic of breaking in occurs in the period of the first hours of the operation.

Usually in plant practice to the breaking in of engine they limit within the limits of two-four hours, accepting it in the following composition:

1) cold run-testing of engine from extraneous drive;

2) the hot of breaking in (in his own engine operation) without load, but with a change in the speed from minimally-stable to nominal;

3) the hot of breaking in with a gradual increase in the load during the constant or variable operating modes.

These engine power ratings compose the basis of acceptance test for each type of piston engine. Further follow regulating-setup works and performance testing and calibration.

Sometimes some plants as a result of the imperfection of testing units, passing cold rolling, they produce only hot to the breaking in of engine, respectively increasing its duration. This testing one ought not to consider equivalent and satisfactory.

Cold rolling not only save liquid propellant, but also raises the quality of the produced engines. In the presence of cold rolling, the engine operation begins after its preliminary training/preparation during which it is obtained not only to the breaking in of the friction surfaces but also the necessary flushing of an entire oil system of engine. For this purpose experimental installation is equipped by special bench lubrication system. the flushing of the oil system of engine is reached because of the increased oil circulation and its intensive filtration during which on the filtering cell/elements occurs the detention of the metallic particles, which separate out with breaking in, and also dust and the contamination, which partially remains after assembly.

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The optimum conditions of the mode/conditions of cold rolling and subsequent hot breakings in depend on the state of the technological process of the manufacture of the parts of engine, especially on quality and accuracy/precision of the machined friction surfaces, and also on the design features of engine. Therefore the selection of the mode/conditions of rolling and breakings in will depend on these factors. Usually it they conduct by step/stages, changing the rate of the rotation of the engine crankshaft after each stage for 100-200 revolutions.

In the case of the sorting/partition of piston engine subsequently, are carried out the monitoring tests, during which the breaking in usually is not produced. However, during the replacement of the critical parts monitoring test must precede additional of breaking in, which in this case is included in the composition of this testing.

For gas turbines as a result of their design features, cold rolling is not required, but the hot of breaking in sharply is reduced. The basis of acceptance tests of these engines comprises: launching/starting and engine warm-up, gradual set of revolutions, regulating-setup works and taking performance characteristics.

Furthermore, for all types of internal combustion engines during test work they occur of work on the elimination of the separate flaw/defects, which are reveal/detected in the process of the operation. The volume of these work depends on the design features of engine and on the degree of its mastery/adoption in production.

The exemplary/approximate composition of the tests of the different types of engines is given in Table 1. It should be noted that the enumeration of the operations, given Table 1, and their duration gives in connection with series production and can change depending on specific technical specifications for the test work, scale and character of production, state of technological process for the manufacture of parts and engine accessories and its design features.

During the determination of the common/general/total labor consumption of tests, it is necessary to consider the volume of the repeated, delivery and control, and also all endurance tests, which are necessary on the average by one programmed engine.

Without taking into account of the specific design features and service life of engine, is not represented possible to determine the

composition of series and other selective endurance tests. They usually are establish/installed conformably for each type of engine, its designation/purpose, scale of batch or program of the issue and other factors.

Composition and the character of the tests of the engines, which studied in operation and passed repair, will actually approach a composition of the delivery and monitoring tests of series production. Composition and the duration of experimental and research tests will be determined in each case depending on the designation/purpose of these tests and tasks which before them are advanced.

The final goal of all tests is taking the necessary engine characteristics.

Table 1. Exemplary/approximate compostion and the duration of the tests of some types of engines.

Наименование испытаний и операций (2)	Режимы испытаний по числу оборотов коленчатого вала (3)	Продолжительность испытаний по типам двигателей в *мин* (1)			
		Автотракторные дизели мощностью 200 *л. с.* (4)	Дизели мощностью 300—500 *л. с.* (5)	Стационарные и транспортные газовые турбины мощностью 100—300 *л. с.* (6)	Транспортные и судовые газовые турбины мощностью 1000—2000 *л. с.* (7)
I. Сдаточное испытание (8)					
Постановка двигателя на стенд	. . . .	15	25	20	30
Холодная обкатка (9)	От минимальных до 0,5—0,6 номинальных (10)	60	90	—	—
Горячая приработка без нагрузки (11)	От минимальных (12) (13) до номинальных	30	30	—	—
Горячая приработка под нагрузкой (14)	То же (15)	60	90	—	—
Прокрутка, пуск и прогрев двигателя (16)	От минимальных (12) (13) до 0,3 номинальных	—	—	10	15
Постепенное увеличение оборотов с выдержкой по отдельным этапам (17)	От 0,3 номинальных до номинальных (18)	—	—	45	60
Осмотр, регулировка, устранение мелких дефектов и подготовка к сдаточному испытанию (19)	. . . .	20	30	40	60
Сдаточное испытание (8)	От минимальных до максимальных (20)	15	30	45	60
Снятие двигателя со стенда (21)		10	20	15	20
Итого в *мин* (22)		210	315	175	245
II. Контрольное испытание (23)					
Постановка двигателя на стенд (24)	. . . . (12)	—	25	20	30
Прогрев двигателя (25)	От минимальных (12) до номинальных	—	15	10	15
Регулировка, наладка и подготовка к контрольному испытанию (26)	. . . .	—	45	45	90
Контрольное испытание (27)	(12) От минимальных (13) до максимальных	—	30	30	40
Снятие двигателя со стенда (22)	. . . .	—	20	15	20
(22) Итого в *мин*		—	135	120	195
Всего в *мин* (28)		210	450	295	440

Key: (1). Duration of tests according to the types of engines in min. (2). Designation of tests and operations. (3). Mode/conditions of

tests according to the speed of the crankshaft. (4). Tractor diesels with a power of 200 hp. (5). Diesels with a power of 300-500 hp. (6). Stationary and transport gas turbines with a power of 100-500 hp. (7). Transport and shipboard gas turbines with a power of 1000-2000 hp. (8). Acceptance test. (9). Setting of engine to stand cold rolling. (10). From minimum to 0.5-0.6 nominal. (11). Hot of breaking in without load. (12). From the minimum. (13). to the nominal. (14). Hot of breaking in under load. (15). The same. (16). Warming up, launching/starting and engine warm-up. (17). Gradual increase in the revolutions with holding in various stages. (18). From 0.3 nominal to the nominal. (19). Inspection, control, elimination of small flaw/defects and training/preparation for acceptance test. (20). From the minimum to the maximum. (21). Taking engine from stand. (22). Sums min. (23). Monitoring test. (24). Setting of engine to stand. (25). Engine warm-up. (26). Control, adjustment and training/preparation for monitoring test. (27). Monitoring test. (28). In all in min.

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In the majority of cases of user, they interest data, that characterize the external work of engine, namely: power, revolutions, the specific consumption of fuel/propellant and oil and some other

data, such as service life of engine, the stability of work under the separate conditions, accelerating, speed and the reliability of starting/launching, temperature conditions, etc.

Therefore of great significance are requirements with respect to the accuracy/precision of these measurements which depend on the methods of measurements, taken bench equipment and metering equipment. However, one ought not to forget that the excessive requirements with respect to the accuracy of the measurements with of taking different characteristics considerably complicate testing unit and its cost/value. The underestimation of these requirements, especially during experimental and research tests, can lead to faulty conclusion/derivations and incorrect conclusions with the supply of final sums.

During the test work of batch production of requirement with respect to the accuracy of measurements, they must be lower than during experimental and research tests.

Table 2. Accuracy of the basic measurements, manufactured during engine testing.

(4) Наименование измеряемых величин	(1) Точность измерений в процентах			
	(2) Поршневые двигатели		Газовые турбины (3)	
	(5) Серийное производство	(6) Экспериментально-исследовательские работы	(5) Серийное производство	(6) Экспериментально-исследовательские работы
Крутящий момент (7)	±1,0	±0,5	±1,0	±0,5
Число оборотов вала двигателя (8)	±0,5	±0,3	±0,2	±0,1
Расход топлива: (9)				
удельный (10)	±1,0	±0,5	±1,0	±0,5
суммарный (11)	±1,0	±0,5	±1,0	±0,5
Расход масла: (12)				
удельный (10)	±1,0	±0,5	±1,0	±0,5
суммарный (11)	±1,0	±0,5	±1,0	±0,5
Расход воздуха на питание двигателя (13)	±2,0	±1,0	±2,0	±1,0
Температура охлаждающей воды на входе и выходе из двигателя (14)	±3,0	±2,0	—	—
Температура масла на входе и выходе, или по всему тракту двигателя (15)	±3,0	±2,0	±3,0	±2,0
Температура воздуха на входе в двигатель (16)	±3,0	±2,0	±2,0	±1,0
Температура отработавших газов на выходе из двигателя (17)	±3,0	±2,0	±2,0	±1,0
Температура воздуха за компрессором (18)	—	—	±3,0	±2,0
Температура газов перед турбиной (19)	—	—	±3,0	±2,0
Давление масла в масляной магистрали (20)	±5,0	±3,0	±5,0	±3,0
Давление топлива на входе в двигатель (21)	±5,0	±3,0	±5,0	±3,0
Барометрическое давление (22)	±0,3	±0,2	±0,3	±0,2

Key: (1). Accuracy of measurements in percentages. (2). Piston engines. (3). Gas turbines. (4). Designation of the measured values. (5). Series production. (6). Experimental research. (7). Torsional moment. (8). Speed of the shaft of engine. (9). Fuel consumption.

(10). specific. (11). total. (12). Consumption of oil. (13). Air flow rate for the feeding of engine. (14). Temperature of cooling water at entrance and exit from engine. (15). Temperature of oil at the engine inlet. (16). Temperature of air at the inlet into engine. (17). Temperature of waste gases at output/yield from engine. (18). Temperature of air after compressor. (19). Temperature of the gases before the turbine. (20). Oil pressure in oil main line. (21). Pressure of fuel/propellant at the engine inlet. (22). Barometric pressure.

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Table 2 gives data on the accuracy of measurements most widely used, that characterize the engine operation during test work in series production or experimental research works, including the tests of separate engine accessories.

§2. Requirements, presented to experimental stations.

The basic requirement, which must satisfy the experimental station, consists in engine tests at station being carried out under

conditions, maximally approximated to operational.

Degree of approximation to these conditions and the composition of tests are usually determined by the technical requirements, developed by design bureaus and confirmed when conducting of the final official (interdepartmental) tests of new specimen/sample or modification of engine.

Contemporary experimental stations in the majority of cases the complex and expensive constructions to which is presented a whole series of requirements. These requirements are mainly explained by the technological process of engine tests, by the need for the creation of the sanitary-engineering and safe working conditions, providing fire safety, by the construction and other basic requirements.

Technological requirements:

1. During bench test of engine, must be provided conditions of its work, as far as possible close to operational.

2. Equipment and equipment of experimental station must provide

high productivity of stands with minimum expenditure of time on installation and disassembly of engine at testing unit.

3. Brake rigging, power-supply systems and maintenance of unit, measurement and control must ensure standard operation of engine and taking necessary characteristics with required accuracy/precision.

4. Experimental station must be equipped with lifting-transporting means, centralized fuel feed and with all forms of energy and industrial supplies.

5. Locations for arrangement/permutation of bench installations and all services of experimental station must have sufficient size/dimensions.

With the planning of the locations of station, it is necessary to consider the possibility of a change in the constructions of engines, for which to provide the possibility of expansion or reconstruction of station for testing the new types of engines.

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6. Planning of arrangement/permutation of stands and station as a whole must be subordinated to rational technological process. In

this case, must be provided the conveniences for the operational maintenance of the equipment of station and tested engines.

For providing the high productivity of stands at experimental stations, it is necessary to have the rational organization of works.

It is necessary to search for ways and methods of the greatest shortening in the auxiliary time, spent on pretreatments, attaining the maximum transfer of these works from stand into preparation department/separation. An increase in the duration of machine work of the test bench the count of shortening the preparatory time, which goes to unit and photography of engine, connection of technological communications and to regulating-setup works, is one of the primary tasks.

At the same time important value has also implementation of the automation of the processes of measurements, recording and processing readings during taking of different characteristics and introduction of programmed control during engine testing.

Sanitary-engineering requirements:

1. Harmful isolation/liberations of vapors and gases, which occur during test work of engines or in process of their training/preparation for tests, both by bench locations and other subsidiary locations of experimental station they must not exceed maximum permissible concentrations, establish/installed from union norms N-101-54 of publication 1958. The harmful isolation/liberations include carbon monoxide, which is contained in waste gases, propellant vapors, oil and acrolein, which appears as a result of burning and heating oil, pairs of mercury (in the case of applying the mercury piezometers) and another harmful substance. In appendix 1, are given the values of the maximum permissible concentrations of these and other, to them similar substances which can have use on experimental stations and the laboratories of the engines where are carried out experimental tests and the finishing of piston internal combustion engines, and in the gas-dynamic laboratories of gas turbines.

At the presence of these harmful isolation/liberations, the maintenance of the necessary sanitary-engineering conditions is achieved by the application/use of suction and exhaust ventilation with the required multiplicity of the exchange of air in the zone of working locations.

2. Provision of all workers at experimental station sufficient,

accordingly the same norms, by size/dimensions of production locations (on area and cubic content), and also by necessary everyday services and locations for arrangement/permutation of operating personnel and employees. All these locations except good ventilation must have heating, water supply and illumination in accordance with the effective norms.

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3. In working locations and services where occurs application/use of toxic and strongly toxic substances (mercury, its pairs and other substances), structures of walls and sex/floor must not absorb these substances.

4. In view of large formation of noises, published during engine testing, it is necessary in experimental stations to use extensively sound-deadening devices and to take special measures of soundproofing, which ensure noise reduction in area of arrangement of experimental station and production indoors to permissible values. Especially this is related to by those to the experimental stations where is conducted testing of gas-turbine and powerful piston internal combustion engines.

The noise level in the working locations in which is possible

the prolonged stay of the service personnel, and also outside experimental station, on the boundary/interface of a sanitary-shielding zone, must not exceed the permissible norms, given in appendix 2.

Requirements for safety engineering.

In work on experimental stations, in laboratories and on separate testing units must be provided the general safety of work of the service personnel. The basic condition/positions of this safety and requirement for it are presented below in chapter VI, §1.

Requirements for fire safety.

These requirements consist in taking organizational and technical measures, which ensure fire safety on experimental stations and laboratories. The basic condition/positions of these conditions and measure are given in chapter VI, §2.

Requirements for building.

1. Constructions of building are must as far as possible to be fulfilled from standard and standard construction parts and cell/elements. All buildings of experimental station must be by sufficiently strong, are carried out in accordance with the existing sanitary-engineering, fire-fighting and other norms for building of the industrial buildings of a similar designation/purpose.

The planning of basic working and auxiliary locations, and also their size/dimensions and architectural shaping must completely answer by the requirements for rational technology of test work.

2. All foundations of experimental station under stands, brake and other power plants must be reliably isolated from all structures of building.

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3. Facing materials of internal surface of locations of test installations must be stable to efflorescence. Construction weeding it must eliminate rapid wear and the isolation/liberation of dust; their surface with the incidence/impingement of oil or

fuel/propellants must not be slippery.

Furthermore, hems and entire/all internal facing of walls must be sufficiently ruggedized and impact loads with random impact/shocks, flameproof and provide the reliable impenetrability of oil and fuel/propellants.

The accumulated over recent years experience in planning, building and the operation of experimental stations and the common/general/total high technological level of the Soviet of all branches of industry create all conditions for the solution and the complete satisfaction requirements enumerated above of basic.

§3. Composition of testing units.

In the composition of testing units, they enter:

1) stand or the engine mount for installation of tested engine;

2) braking device;

3) device and the systems of launching/starting, control,

heat-control/check, measurements of power and other parameters of engine;

4) the power-supply system and maintenance of testing unit;

5) the sound-deadening other devices and systems - as needed.

Basic and main link in testing unit is braking device whose basic designation/purpose is absorption of the power, developed with engine in the process of its testing, and the measurement of brake horsepower with the required accuracy/precision. The most general-purpose form of brake is such reversible machine which alternately can work as brake and as drive for starting/launching or cold run-testing of engine.

The correct and rational selection of brake is decisive for an entire experimental station. This selection superimposes the determined character on the composition of tests, the organization of works within experimental station, its operation, saving, and in certain cases for the type of locations and required area.

All the other equipment, systems and the devices of experimental station are subsidiary, that ensure operation of engine on stand and conducting the proper measurements and monitoring of all parameters, which characterize tested engine.

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Chapter II.

BRAKES AND BRAKING DEVICES.

§1. General recommendations by choice of brake.

In the beginning of the design of testing unit or selection of equipment first of all and mainly must be solved the question concerning brake and braking device. When selecting brake, must be solved the following basic questions:

1. Determination of the type of braking device for the satisfaction of the following technological requirements: need and the provision for warming up of engine during its starting/launching; the need for cold rolling and methods of its conducting; the provision for braking engine under the conditions of work, the

conformity of power and revolutions of tested engine under these conditions with possibilities and the characteristic of brake; determination of a required quantity and type of testing units in connection with the selection of braking device for conducting the different series, commission, standard and other tests and the determination of the possibility of the unification of these installations; the provision for power measurement of engine with the necessary accuracy/precision.

2. Economic, connected with study possibilities and advisability of recuperation of mechanical energy, developed with engine during its testing. Since most convenient from the viewpoint of the methods of obtaining and use of the taken by the brake from the tested engine energy is electrical energy, braking device in this case must be simultaneously and the generator of alternating or direct current with the conversion of the latter into variable.

With the studying of economic considerations and substantiation, are must, to be taken into account initial capital investments on the acquisition of the brakes of their power-supply systems and maintenance, and also operating costs and the periods of the absorption of this equipment.

3. Organizational and technical, directed toward realization of

complex overall mechanization and automation of processes of tests in series and mass production of engines and in particular introduction of programmed control during engine testing, which is also connected with selection of type of braking device.

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Since the basic equipment of unit is intended for the prolonged period of operation, when selecting brake, also must be studied the questions, connected with the promising possibilities of the rearrangement of production or changes in the characteristics of tested engines. Thus, for instance, with a possible promising increase in the power of engine the power of brake group can be subsequently twice size because of setting into the tandem of second the same brake. In this case the shaft of brake must be selected or ordered from the condition of the transmission by it of the doubled power. Must be also examined the questions, connected with the possibilities of the realization of order for brake rigging: construction, manufacture, delivery specifications, installation and its adjustment during introduction into operation.

For the solution to these questions, one should examine the basic types of brakes, reveal/detect/expose their comparative evaluation, the possibilities and the fields of application.

§2. Brakes.

1. Classification of brakes.

Since the power, transferred from the shaft of engine, is absorbed by the resistance of the given machine, the value of this resistance determines the load of engine. For determining the power of engine during its testing, is applied the artificial load of engine in the form of resistance from the special device, called brake. During the rotation of the shaft of engine, the loading device, namely, the stator of brake, absorbs reactionary torque, equal to the torsional moment of the engine which is balanced by the weight or other strength measuring device of brake. With the aid of this measuring system is determined by force P on arm R. The multiplication of these values will give the torsional moment M_K. Knowing speed per minute, equal n, it is possible to determine effective shaft horsepower of engine N_e, which is determined from known from mechanics to the expression

$$N_e = \frac{M_\kappa n}{716{,}2} \text{ л. с.} \quad (1)$$

Key: (1). hp.

On the principle of operation and its device whole of the brake, used for engine testing, can be classified according to the following basic groups:

a) mechanical;

b) air;

c) hydraulic;

d) electrical;

e) induction;

f) combined.

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2. Power brakes.

In power brakes the power of tested engine is absorbed by the friction of shoes or brake band against the quill sleeve of engine block.

In this case the torsional moment of engine is determined with the aid of the lever, fixed to shoes to end of which are hung up the loads, or it affects weight mechanism or dynamometer.

To main disadvantages in these brakes, one should relate the need for the frequent control of brake in view of the inconstancy of the coefficient of friction between the block and shoes or between bands and the block, and also the difficulties, connected cooled of the brake pulley by the water, the presence of spatter during operation and others.

As a result of these essential shortcomings the at present power brake are not virtually applied.

3. Air brakes.

For air brakes can be applied propellers, fan brakes, the simplified screw/propellers or bars with the blades, which are mount/fited directly to the shaft of engine or from the latter are given to rotation. In all cases the power of engine is absorbed by air resistance. The determination of power in this case can be produced by three systems: by applying the bob frame on which is establish/installed the engine, on rigid stand with the aid of previously calibrated air brake, either with the aid of torque meter which is installed on brake or between the engine in air brake.

In the first case reactionary torque from air brake, equal in absolute torque of engine, is transferred from brake (screw/propeller or fan brake) to engine and frame and is caused its deviation around longitudinal trunnion to the side, reverse/inverse to the rotation of the shaft of engine. Frame is connected with weighing device or dynamometer, with the aid of which is measured the effort/force, developed with tested engine. The torsional moment and the power of engine are determined from formula (1).

In the second case in the presence of rigid stand, to measure the torsional moment is not represented possible. Therefore the determination of power is produced on revolutions and the calibration

graph of this air brake, comprised on the standard engine whose characteristics are removed preliminarily at another special arrester.

In the third case the determination of power is produced at the torsional moment, measured with the aid of torque meter or with the aid of dynamometric clutch.

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Change or the control of the load of air brake is produced by applying air adjustable-pitchs propeller or by the rearrangement of load blades. The latter is produced by hand after the engine shutdown.

Air brakes find a use during testing of air-cooled engines, including aviation piston and turboprop engines. This is explained to the facts that propellers and fan brakes, being rotated, is created simultaneously and air flow, necessary for engine cooling. Furthermore, air brake imitates the actual operating conditions of the operation of these engines, that sometimes is necessary to create during testing.

To shortcomings in air brakes, one should relate relative

unwieldiness of testing units, the need for their arrangement/permutation for the isolated/insulated boxes, the high cost/value of the sound-deadening devices due to the large dimensions of intake and exit sections. To this one should consider economic unprofitability and the practical impossibility to utilize energy of engines during their testing on these brakes.

In the first case of applying the bob stand with air brake, the accuracy of the measurement of power can be raised because of the account of corrections for blowout from the acceleration of air flow by the time/temporary setting up of diffusor grid between the screw/propeller and the engine. In the correctly selected and assembled strength measuring systems the accuracy of measurement can be reached within limits from ±0.5 to ±1.0o/o of maximum value of measurement.

In the second case this accuracy/precision virtually can be reached little more than within limits from ±1.0 to ±2.0o/o.

In the third case depending on the used constructions of the torque meters and dynamometric clutches, the accuracy of measurement ranges from ±1.0 to ±3.0o/o.

4. Hydraulic brakes.

The principle of work of hydraulic brakes is based on liquid resistance to the displacement/movement of the rotating part of the brake - (rotor) in housing - (stator), which has bob suspension and the measuring system of the torsional moment. By construction these of brake are subdivided into disk, that have into rotor several disks with finger/pins or holes, and spherical with the shaped rotor on which there are oval pockets or blades with the symmetrical arrangement of the same pockets or blades on stator.

The power of disk brakes is usually regulated by means of the filling of them with water. Such of brake with the light loads of engine work unstably, what is their essential shortcoming.

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The majority of brakes with the spherical shaped rotor is regulated according to power by changing rotational resistance of rotor by the cover of water by the shutter/valve, which moves between the rotor and the stator, and also a change in the consumption of the water through the rotor. Such of brake, although they are more complex, during all load mode/conditions work stable. The

longitudinal section of this brake is given in Fig. 1.

The stator of hydraulic brake, absorbing the torsional moment of engine, because of its bob suspension it attempts to turn itself to the side of the rotation of shaft. In this case, it is balanced by the measuring system of the torsional moment, which usually together with calibration instrument enters in the assembly of supply of system.

The control of power during a change in the load of engine can be manual or mechanical. During load, change new mode/conditions is establish/installed only after certain time after control.

Especially this is related to the brakes which are regulated by means of filling with water, what is an essential shortcoming in the hydraulic brakes. Possessing the large power reserve, hydraulic brake are sufficiently compact and have relatively small overall dimensions. Therefore they can be manufactured within the limits of the large power range and speeds.

Fig. 2, gives the general view of the slow hydraulic brake of firm "Quinane-Froude" by the power of 17,500 ~~л. с.~~ hp with 90/200 r/min.

The majority of brakes of this type, intended for work during

the rotation of shaft in both directions, are manufactured reversive.

One Their essential shortcomings in the hydraulic brakes is that fact that they cannot create the large torsional moment on low revolutions. Therefore they have the slanting characteristic, shown in Fig. 3, somewhat being inferior in this respect to electric brakes and even in larger measure induction. For the partial elimination of the mentioned shortcoming, sometimes it is necessary to apply more powerful hydraulic brake how this is required for this engine. Absorbed by hydraulic brake mechanical energy transfer/converts to thermal, which is transferred primarily by flow water. The insignificant part of the heat is emitted into the surrounding atmosphere.

A required quantity of cooling water for a hydraulic brake can be theoretically determined from the equation of the heat balance

$$Q_h = 632N_e = G_h(t_{вых} - t_{вх}),$$

whence

$$G_h = \frac{632N_e}{t_{вых} - t_{вх}} \text{ л/ч}, \quad (2)$$

where Q_h is a quantity of heat, abstract/removed by water from hydraulic brake, in kcal/h;

632 - the quantity of heat, isolated per hour 1 h.p., in kcal/hp hr.;

N_e is effective power in h.p.;

G_h - a quantity of water, passing through the hydraulic brake for 1 h, in 1/h;

$t_{\text{вых}}$ is temperature of the water, coming out from hydraulic brake, in °C;

$t_{\text{вх}}$ - the temperature of the water, entering the brake, in °C.

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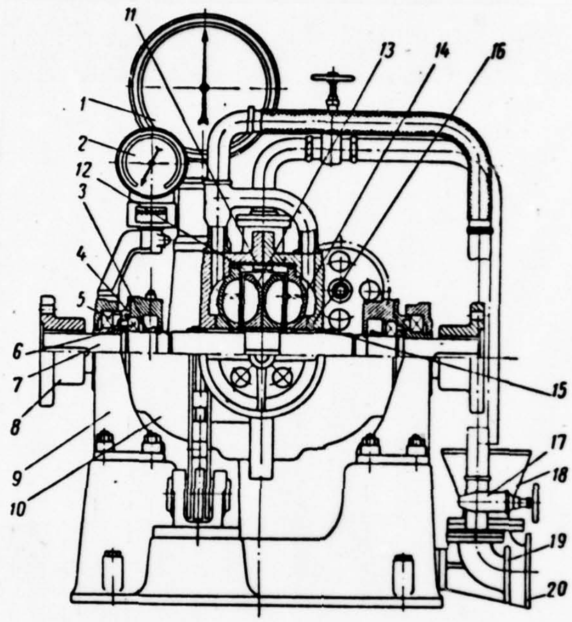

Fig. 1. Longitudinal section of hydraulic brake: 1 - dynamometer (weight head); 2 - tachometer; 3 - regulator of tachometer; 4 - lock of bearing; 5 - radial bearing of stator; 6 - main bearing; 7 - shaft; 8 - half-coupling; 9 - buck stay; 10 - lower half-yoke; 11 - shutter/valve; 12 - hole for yield of water; 13 - rotor; 14 - elliptical pockets of stator; 15 - pack(ing) nut; 16 - stuffing-box seal; 17 - valve/gate of feed control of water; 18 - drainage funnel; 19 - flange of feeding water pipe; 20. the flange of discharge lead.

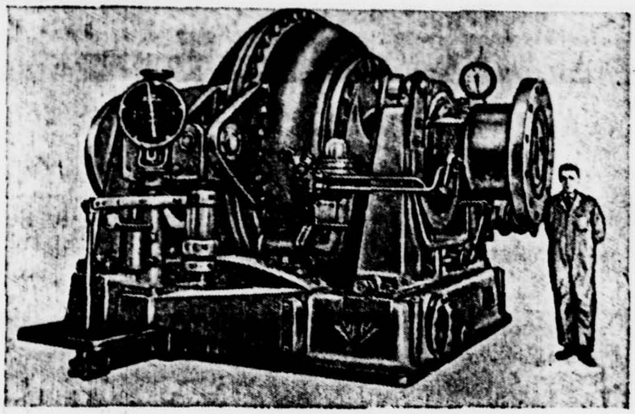

Fig. 2. Overall form of Quinane-Froude hydraulic brake with power of 17,500 h.p. with 90/200 r/min.

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To avoid the formation of vapor locks, which disturb the circulation of water, for providing the stable operation of hydraulic brake the temperature of the coming out water must be not above 60-65°C. When the closed power-supply system of hydraulic brakes is present, by water its temperature in summer is 25-30°C. At these values the consumption of water will be about 20 l on 1 h.p. in hour.

With feeding from water-conducting mains, the consumption will be about 15 l on 1 h.p. h. The majority of brakes for stable work

requires the provision for creation of constant pressure at the entry into hydraulic brake. This is reached by the setting up of the regulator of constant pressure on the feeding line of water pipe or by the arrangement of tanks at height/altitude from 3 to 4 m above the level of hydraulic brakes. In this case, the fixed level of water in tanks is supported by float mechanism.

The duration of the operational service life of work of hydraulic brakes is determined mainly by the wear of the internal surfaces of water cavities. This wear especially grow/rises when there are present in water mechanical impurities which as a result of the high speeds of the motion of water and under the effect of cavitation destroy the metallic parts of the water cavities of brake. In spite of shortcomings indicated above, hydraulic brakes because of their power, compactness and universality find wide application during testing of the different types of engines.

5. Electric brakes.

Recently in connection with the research in the USSR of the new methods of regeneration and the wide development of electrical engineering industry, everything in larger scale find a use electric

brakes. They are deprived of the indicated shortcomings ~~+~~ and they are machines reversible. In the majority of cases as electric brakes, are utilized the electric motors of direct and alternating current.

They serve as drive for cold rolling and starting/launching during hot tests or taking of friction horsepower.

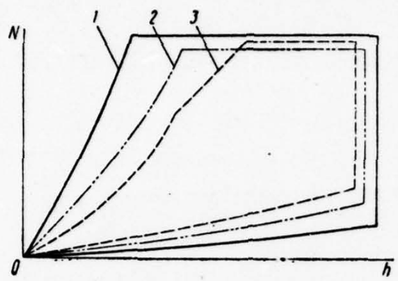

Fig. 3. Comparative characteristics of brakes: 1 - induction brake; 2 - electric brake (machine of direct current); 3 - hydraulic brake.

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During the transfer/transition of engine testing for its own work (thermal process) the power, developed with engine, is transferred to the electric brake which in this case works as generator. Thus, the mechanical energy, developed with tested engine, is converted into electrical, that can be usefully used:

E
everything electric brakes possess good stability in all operating modes and provide convenient and continuously variable control of the load of engine.

As electric brakes for engine testing of internal combustion, can be used the following electrical machines:

a) the electric motor of direct current in common performance;

b) the bob machine of direct current;

c) asynchronous electric motor with phase rotor and with the control of resistance, included in the circuit of rotor;

d) asynchronous or synchronous electric motor with magnetic slip coupling;

e) the same, but with hydraulic clutch of slip or hydraulic converter.

During operation of any electrical machine, its stator as a result of the action of magnetic forces absorbs the torque/moment, equal to the torsional moment of the tested engine which rotates armature shaft. Therefore, if the stator of electric machine has the bob suspension, connected with weight mechanism or dynamometer, then it will be possible to measure this torsional moment, but by it and corresponding to it to revolutions to determine the power of engine is analogous with power measurement on brakes examined above.

The same effect can be obtained, if electric motor in common performance will be establish/installed to the bob frame of stand or, on the contrary, during the rigid fastening of the housing of electric brake tested engine will be located on bob platform.

From the viewpoint of the measuring technique, all these methods are equivalent. However, is more convenient stand for an engine to have rigid, and electric brake to accept with the bob suspension of stator or to establish/install electric brake upon bob platform.

In work of electric machine in motoring, i.e., as electric servomotor, the torsional moment will be determined by the power input of the given by it tested engine and will be directed to the counterrotation of anchor. In generator mode, i.e., during braking of tested engine, the torsional moment on stator is equal to the torsional moment of engine and it is directed to the side of the rotation of anchor.

For the contemporary constructions of dynamometers in the correctly selected system of bob suspension by electric brake can be reached the accuracy of the measurement of power within limits of ±0.25-0.5o/o from the maximally measured effort/force.

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In the case of applying the electric motors in common, stationary performance and with failure on the stand of bob device in an indicated manner to measure the torsional moment is not represented possible. In this case the power of tested engine is determined only from wattmeter. As a result of losses in electric machine and mains of the electrical devices, which are variable values, the accuracy/precision of power measurement in an indicated manner will be located of 3-5o/o.

The bob machine of direct current is one of the most modern and general-purpose brakes. This type of brake frees from the need for the device of bob frames or platforms.

For the machines of direct current the most convenient method of feeding and controls over a wide range of revolutions and braking moment is Leonardo's diagram, extruded by the recently mercury adjustable rectifier. In this case, each bob machine during its work is serviced by one aggregate/unit, which are of the electric motor of alternating current and the given by it direct-current generator, or one mercury adjustable rectifier. The power of this conversion unit

as a result of some losses is accepted somewhat higher than the power of bob machine. Usually conversion units are accepted in a quantity smaller than the number of bob machines, since is considered the diversity factor of their work. In this case is provided for the possibility of the connection of bob machine to any of that which are being, or to any of the group of conversion units, that which was not occupied at given torque/moment.

Despite the fact that this type of electric brake with converter requires several large initial capital investments, all the same it makes it possible of its wide use during tests according to different programs. Besides conducting of rolling, warming up for starting/launching and braking, it also provides taking friction horsepower, the determination of efficiency, but during endurance tests it still makes it possible to carry out regeneration. This is why this type of electric brake successfully is applied for research and standard tests of the different type of engines, especially in pilot plants and experimental laboratories. The general view of bob machine with the beam balance measuring system of the torsional moment is given in Fig. 4.

From series specimen/samples at present Soviet industry supplies bob machines, also, to them conversion units up to 800 kW in thickness. During connection into the tandem of such two machines,

the total power can be obtained to 2000 hp. The manufacture of more powerful machines requires individual order.

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To common shortcomings in electric brakes, one should relate their limited possibilities the range of maximum revolutions. Of the electrical machines of direct current by power from several dozen to 800 kW the maximum rpm compose with respect to 6000-4000 r/min. For all electrical machines of larger power, maximum speeds will be within limits 1500-3000 r/min. The use of electrical machines for braking of the high-speed engines, which have on output shaft the speed, which exceeds the permissible revolutions of electric brake, is possible only in that case if between the tested engine and the electric machine will be introduced the reducer, which depresses the transferred revolutions. However, with large powers and high revolutions, this reducer will represent complex aggregate/unit. To account for in the reducer of losses; which are the value of variable, it is necessary it to install on common/general/total dynamometric platform (according to type Fig. 10k) or to place on independent bob suspension with their own measuring system. Such solutions considerably complicate testing unit. Therefore they can find finding. Shortcomings in the separate constructions of powerful electrical machines include also the need for the device of basements

for the arrangement of ventilation systems for the purpose of supply from below the machine of air for their cooling.

In comparison with the hydraulic brakes of electric brake, they have somewhat more steepness (see Fig. 3) and more convenient control system, that better yielding to automation.

6. Induction of brake.

Induction of brake are based on the interaction of vortex/eddy Foucault currents and magnetic flux, formed during inductor in stator which has circular field coil. Inductor or rotor is the rotating part of the brake and is the double-row gear, manufactured from low-carbon steel for providing good magnetic permeability. Teeth in section/cut have rectangular or trapezoidal form and do not require the high accuracy/precision of the manufacture of their airfoil/profile.

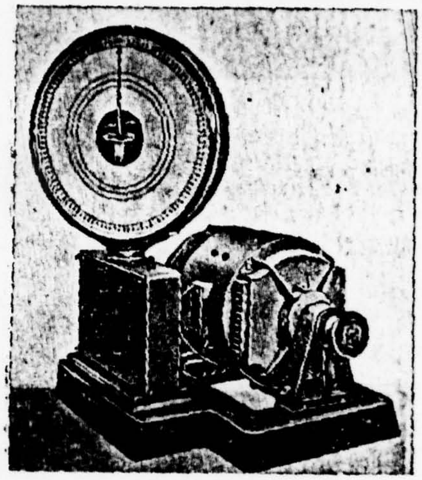

Fig. 4. General view of bob machine with beam balance dynamometer.

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Inductor is arrange/located in the stator, which consists of two halves within which is placed the field coil whose plane is perpendicular to longitudinal brake axle. The schematic diagram of induction brake is given in Fig. 5.

Within stator are inserted the steel sleeves, which possess large magnetic permeability. For providing the equal to permeability, air gap between the inductor and sleeves must be as far as possible minimum.

During the excitation of coil by direct current is formed the circular magnetic field, which magnetizes the teeth of the inductor of each series by unlike poles, as this is shown in Fig. 5. As a result of this on the edges of the teeth of inductor, are formed the local concentrations of magnetic flux. During the rotation of rotor, the surface of the internal sleeves above and between the teeth of inductor on turn is magnetized and is demagnitized, in consequence of which in sleeves appear the eddy currents. The interaction of vortex/eddy Foucault currents with resulting magnetic field of machine creates required braking moment.

For its determination the housing of stator has bob suspension and measuring system analogous with bob electrical machines. The torsional moment, received by stator, is directed to the side of the rotation of shaft. The longitudinal section of the general view of induction brake is given in Fig. 6.

Thus, occurs the conversion of mechanical energy into electrical and further - into thermal. Basic part of thermal energy is transferred to stator and partially to rotor. For the removal of this heat within brake, is provided for the system of water cooling. There are constructions of the brakes into which the water is passed

through stator-rotor unit, or only through the stator. In the latter case the excess heat is transferred to stator by emission/radiation. The cooling system of the first requires the provision of constant pressure at the entry into brake, since water, which is located between the rotor and the stator, during pressure change in supply line can influence the stability of work of brake. In other constructions the water for larger cooling efficiency enters stator under the pressure of water-conducting mains; changes in this pressure do not affect the operation of brake, since the rotor is not filled by water. The specific consumption of water on 1 h.p. will be the same as and for hydraulic brakes, and is determined from formula (2).

The limiting value of braking moment is determined by the density of the magnetic field of the teeth of inductor. Even at the low speed of rotation this torque/moment composes the significant magnitude. Therefore the characteristic features of induction brake consist in the fact that it, possessing high energy content, it can develop complete brake horsepower already at the speed of rotation, component only 20-25o/o of the complete revolutions. Therefore its brake characteristic goes steeply upward, considerably anticipate/leading the characteristics of all other brakes (see Fig. 3).

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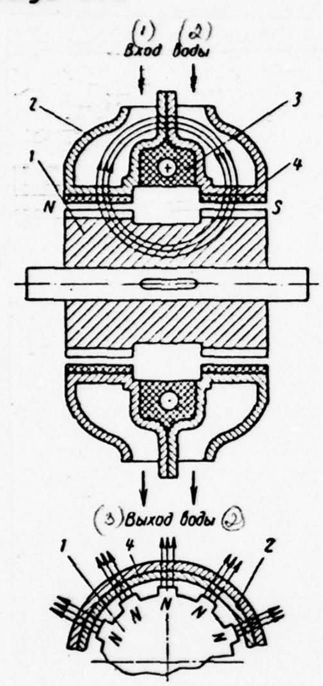

Fig. 5.

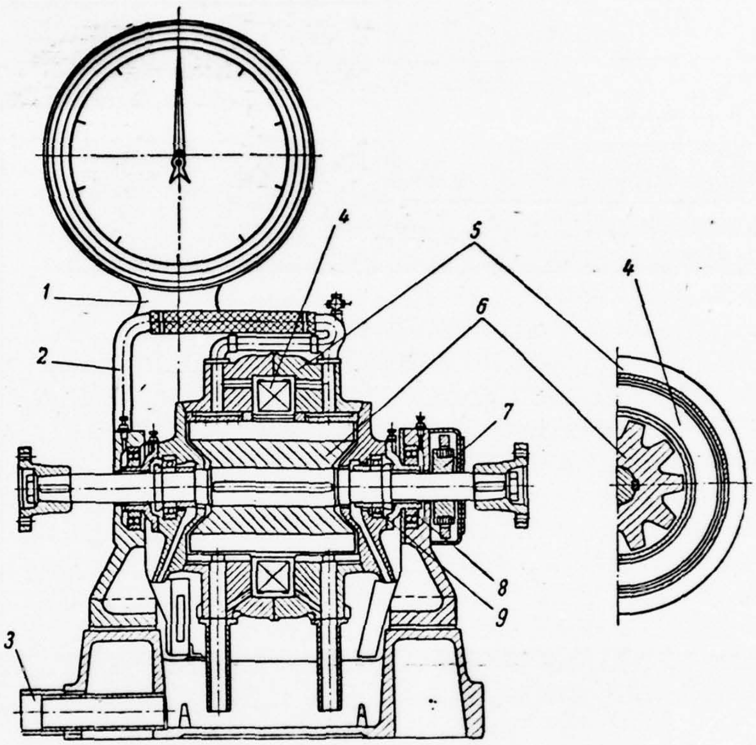

Fig. 6.

Fig. 5. Schematic diagram of induction brake: 1 - inductor (rotor with teeth); 2 - stator (front/leading half); 3 - field coil; 4 - sleeve.

Key: (1) Input; (2) Water; (3) Output.

Fig. 6. Longitudinal section of induction brake: 1 - dynamometer (weight head); 2 - feeding water pipe; 3 - drainage water pipe; 4 - field coil; 5 - stator; 6 - inductor (rotor); 7 - generator of automatic control; 8 - holder of bearing of bob suspension; 9 - shaft bearing of inductor.

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This is the very valuable special feature/peculiarity of induction brakes, since in a number of cases only they can ensure braking the engines and other mechanisms (different hydraulic transmission, hydraulic converters, electric motors, etc.) if necessary for their testing according to abrupt/steep brake characteristic.

The power, required for the feeding of field coil, is insignificant, it comprises less than 0.4-0.5o/o of the power of brake. This feeding by direct current can be realized from the selenium rectifier or another source. The control of the load of brake is achieved by a change of the current strength in field coil. In view of the fact that this control is sufficiently simple and reliable, it easily can be automated.

Induction brake is the reversive irreversible machine, since it is incapable to work in motoring as drive, what is its essential shortcoming. However, the characteristic feature of this brake is that it barely has any limitations of application/use, with the exception of strength, and therefore it can be created to the wide range of revolutions and powers, including high-speed of brake. The duration of its operational resource/lifetime is sufficiently great and can be equal to electrical machines. In recent years induction of

brake in us and abroad received wide acceptance. Many leading motor vehicle plants and some engine-building plants successfully their are utilized and they further expand the field of their application/use. Fig. 7, gives induction brake by the power of 6000 h.p. with 1500/3000 r/min of firm "quinane-Froude", paired of two brakes on 3000 h.p. each.

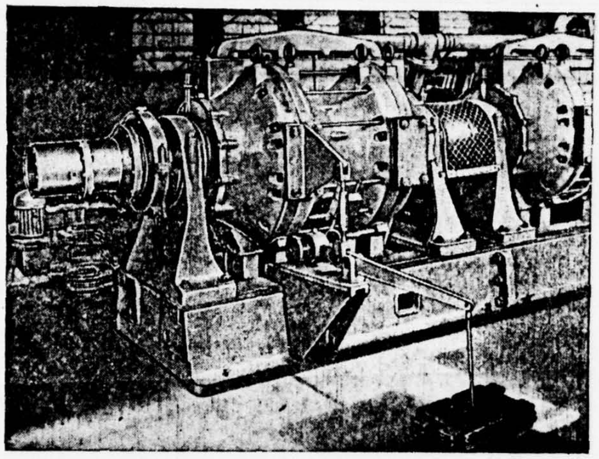

Fig. 7. General view of induction brake Quinane- Froude, that is of two machines, connected into tandem, overall power of 6000 hp. Power of each brake 3000 h.p. with 1500/3000 r/min.

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§3. Braking devices.

Braking devices, adjustable between the tested engine and the brake, include mainly the clutches of cohesion/coupling, reducers and slipping clutches. The latter combine in itself the functions of first two, i.e., cohesion/coupling engine with brake and the reduction of speed.

Therefore slipping clutches, which are the rational combination of two devices, had extensive application in propulsion test facilities.

1. Magnetic slip couplings.

Electromagnetic (induction) slipping clutch is intended for the smooth conversion of the rate of the rotation of the shaft of driving/homing engine to the given aggregate/unit-brake. This clutch seemingly replaced by itself reducer with unlimited gear ratio. Electromagnetic coupling is created according to the principle brake examined above of induction and consists of two half-couplings. One Of them is connected mechanically with electric motor, and the second is inductor and it is arrange/located within the first - the anchors, isolated in the circumference between themselves the low air clearance. The schematic diagram of electromagnetic coupling is shown in Fig. 8.

Inductor is double-row gear made of low-carbon steel with the rectangular or shaped teeth and has one circular field coil whose

axle/axis coincides with the axle/axis of the shaft of clutch. The teeth of the inductor perform the role of the magnetic poles of electric machine.

Anchor also is fulfilled made of low-carbon steel and has longitudinal slots in internal part for an increase in the transferred torque/moment and groove/slcts cn exterior - for an improvement in the ventilation cooling of clutch.

The general view of electromagnetic coupling is given in Fig. 9.

If we set in motion the inductor over coil of which occur/flow/lasts direct current, then the internal part of the anchor, turned to inductor, will experience/test a change in the magnetic flux. This will cause the formation of eddy currents in this part of the anchor. The interaction of vortex/eddy armature currents with the magnetic flux of inductor creates the torsional moment of clutch. Than is more field current and the greater the slip of clutch, i.e., the relative rate between the anchor and the inductor, those will be more eddy currents, and consequently, the greater there will be the torsional moment, transferred by clutch.

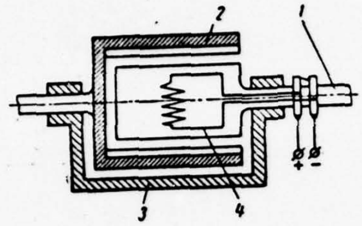

Fig. 8. Electromagnetic slip coupling: 1 - leading half-coupling; 2 - driven half-coupling; 3 - housing of clutch; 4 - field coil.

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This property of induction clutch makes it possible to regulate the rotation of the shaft of tested engine in the process of cold rolling, and to also obtain the constant velocity in the shaft of electric motor at the different rates of the operation of tested engine under load. During the cold rolling when electric motor works in motoring as driving/homing engine at the constant rotational speed, at the initial stage of rolling, the revolutions of shaft of tested engine they must be small, in this case in clutch, occurs large slip and field current will be small. For the increase in the speed of the shaft of engine, which passes rolling, field current in clutch it is must increase, and its slip decreases. During tests under load in the initial stage when the revolutions of the shaft of

the test engine even lower than nominal revolutions of electric motor, clutch it works without slip and field current in it will be large. If necessary for a further increase in the speed of tested engine, one should decrease the current of excitation. In this case, the slip in clutch it will be the greater, the more the revolutions of the shaft of tested engine they exceed rated r/min of electric motor. Last/latter, having constant velocity, it can work as brake and as current generator, i.e., recuperated work. In that case for these purposes, can be used the machines of alternating current.

As a result of slip in clutch will occur the loss of certain part of the energy in the form of the heat, emitted into surrounding air. These losses they will be the greater, than the more transmitted power and is more slip. Therefore construction described above of clutch reliably works only at power to 500 hp. At the larger power of slipping clutch in the case of continuous operation, they require the introduction of additional cooling, which complicates the construction of clutch. A change of the field current in this clutch, and consequently also its control, can be automated.

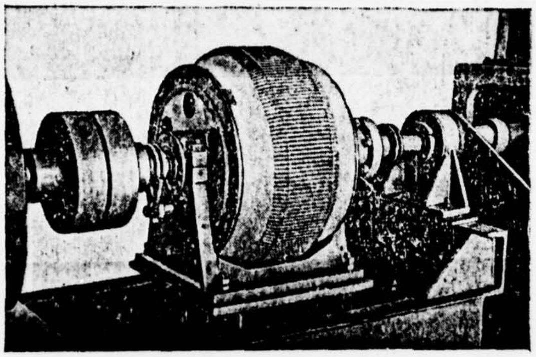

Fig. 9. General view of magnetic slip coupling.

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Chapter III.

TYPES OF TESTING UNITS.

§1. Testing units without regeneration.

The mechanical energy, developed with engine during its own work (heat-engineering tests), in its majority usefully is not utilized, but it is only absorbed by brake.

Reason to this they are mainly: the small duration of tests, frequent changes in the operating modes, complexity and high costs of recuperation devices, are not created the economic effect, obtained from the use of mechanical energy of engine.

Only mass production, which requires the continuous conducting

of the heat engineering tests of several engines is simultaneous, are created the economic advisability of the organization of the constant use of mechanical energy of engines and its transformation (recuperation) into electrical for the needs of the production or other target/purposes.

Let us examine at first thermal testing units without recuperation according to their types and designation/purpose. The type of testing unit is determined mainly by designation/purpose and the character of tests, by type and the power of the engines, which are subject to tests.

Usually testing units are called on braking device, since the type of brake has decisive effect on the character of an entire unit.

In the diagrams, given Fig. 10, shows the possible versions of the arrangement of braking devices at testing units. Support systems and the accessories, which forms part of these installations, on diagrams are not conditionally shown.

Let us examine the basic possible regions of use of separate installations according to their types.

1. Unit for cold run-testing of engines. (Fig. 10a).

If necessary of conducting cold rolling and impossibility of its realization at basic test benches are accepted special stands according to the indicated diagram.

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As drive for them, serves the electric motor of direct or alternating current. Direct-current motor will require electric power supply from the conversion unit which can service several stands. With this engine can be provided continuously variable control of speed in the different mode/conditions of cold rolling.

During the use of an electric motor of alternating current, its control can realize/accomplish only by step/stages with the aid of charging resistance.

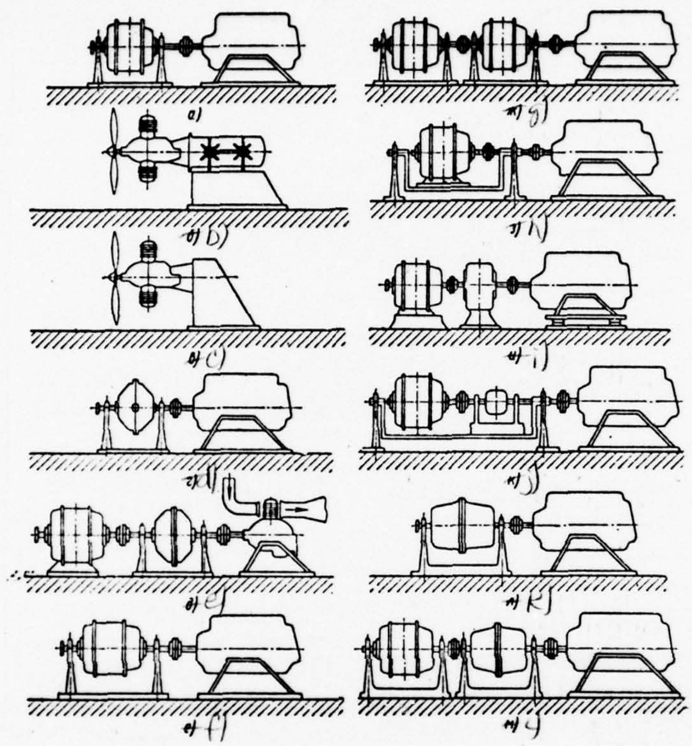

Fig. 10. Schematics of the testing units: a) unit for the cold rolling of engines; b) bob stand with air brake; c) rigid stand with air brake; d) hydraulic-brake testing unit; e) hydraulic-brake testing unit with forced blowout and starting/launching electric motor; f) electric brake unit with the bob machine of direct current; g) electric brake unit with two bob machines of direct current; h) electric brake unit with the machine of direct current, establish/installed on bob platform; i) electric brake unit with hydraulic coupling and electric motor of alternating current (tested

engine - on the bob platform); j) electric brake unit with magnetic slip coupling and the electric motor of alternating current, establish/installed on bob platform; k) testing unit with induction brake; l) the combined, brake testing unit.

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At such units for rate, change can be also used gearboxes and the special clutches, which convert the revclutions of electric motor during transmission to the broken in an engine. Since the cold rolling is required only for piston engines, the field of application of these installations to these engines is limited.

A shortcoming in the organization of conducting cold rolling at special burnishing stands is the unavoidable in this case expenditure of time for additional setting and photography of engine, which on the general-purpose stands where is combined rolling with heat test, is absent.

The necessary power of electric servomotor will depend on construction and power of the broken in an engine and required revolutions of shaft during its rolling. If greatest speed during rolling is accepted in size/dimension of 60o/o of nominal engine

revolutions, then the necessary driving power will comprise approximately 12-15o/o of nominal power of engine. In this case, the sparkplugs or fuel injectors in jugs must be inverted.

2. Bob and rigid stands with air brake (Fig. 10b and c).

On these testing units basic information and the field of their application/use is given above.

Here one should add that in the case of applying the testing units with propellers for their normal operation must be created the specified aerodynamic conditions, under which the outline/contour of the location of unit must have minimum resistance. Air flow before the screw/propeller must be rectilinear, with uniform density, and screw/propeller itself must be furnished in diffuser or in diaphragm. The examination of these installations does not enter in our problem.

3. Hydraulic-brake testing unit (Fig. 10d).

Hydraulic-brake unit can be used for testing the different types

of the piston internal combustion engines and gas turbines. This unit can be used when cold rolling is not required (or it is carried out on the separate stands), but engine starting on wall can be produced from its starter.

For the feeding of hydraulic brake, the unit requires supply and derivation, also, in many instances with the provision for a pressure constancy at the entry into brake.

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When, at the experimental station, several hydraulic-brake installations are present, is expedient the device of closed system cooled of circulation water in saltpan or the spray pond. The cooling system can be common with other water users in enterprise. In the case of water supply from water-conducting grid/network, is necessary the unit of the mixing tank which simultaneously can be forcing with ejection of the excess of water into channelization.

4. Hydraulic brake unit with blowout and starter electric motor. (Fig. 10e).

This unit is characterized by from preceding/previous the presence of the system of forced blowout and the additional unit of electric motor for starting/launching or warming up of tested engine. Is applied it mainly for testing of various piston internal combustion engines of air cooling or for experimental works on single-cylinder unit. It can also be applied either only with ventilation system, or only with additional electric motor. The latter is selected depending on the conditions of starting/launching or warming up and can be direct or alternating current with feeding to the similar electric motors of the installations of cold rolling.

After starting/launching starting/launching electric motor automatically is disconnected from hydraulic brake with the aid of by-pass or electromagnetic coupling of cohesion/coupling. The ventilation system of unit is determined by a required quantity of cooled air and by air-stream velocity. The air duct of blowout can be fed to engine on top, from the side or from below braking device.

For installations with forced blowout, the intended for testing piston air-cooled engines with one or several cylinders, the air flow rate can be approximately determined by the following formula, obtained **experimentally:**

$$Q_{ox} = 0{,}67{,}5\left(\frac{N_l}{t_{ц} - t_{ox}}\right)^{1.4} \text{ kg/s}, \qquad (3)$$

where Q_{ox} is air flow rate for engine cooling in kg/s; N_i is the indicated power of engine in h.p.; t_{u} is temperature of cylinder head of candle in °C; t_{ox} is temperature of the air, supplied to engine, in °C.

For cooling of such engines, usually is provided for independent system with high-pressure fan. Air duct for engine cooling must be as far as possible conducted nearer to jugs. Air after cooling can head for the receiving branch connection of ejector tube or for the special exhaust system.

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5. Electric brake units with the machines of direct current (Fig. 10f, g, h).

The unit with one bob machine of direct current, shown in Fig. 10f, is general-purpose and can be used for testing the wide circle of the different types of engines with the speed of output shaft not more than 4000-6000 r/min, depending on power and the construction of

electric brake equipment. A similar unit requires the feeding by electric power of the conversion unit: motor generator or mercury rectifier, which as far as possible must be furnished near the test bench. Due to high cost/value and the complexity of electrotechnical equipment, this unit is applied mainly for standard, control or experimental tests. The unit in question during continuously variable control of the speed from minimal-stable to maximum revolutions provides the high accuracy of measurements of the torsional moment.

Analogous to the preceding/previous Fig. 10g shows arrester with two bob machines of direct current, arrange/located tandem. This articulation is necessary when are encountered difficulties in obtaining of the bob machine of the required power or the available in the presence machines are insufficient with power. A double increase in the power of brake group is necessary and when on one stand test different in power engines. During testing on this stand of subminiature motors, the second brake is disconnected, and for high-powereds engine both brakes work together. In the paired work the measuring system of the torsional moment can be common/general/total, when the stators of electric motors are connected by common/general/total lever/crank system or equipped with individual measuring systems. In the latter case of reading both dynamometers or weight heads, they are totaled.

It is necessary also to keep in mind that in the joint operation of both electric motors the shaft of the first of them will bear double load, and therefore its strength must be provided by the limits of allowable stresses on torsion. Some types of the bob machines of catalogue mark/brands have shafts, which allow for of the transmission of double power.

In any case this strength requirement must be specified with the order of machines, in each individual case checked them, if such machines are in the presence.

Besides installations examined above with bob machines, for a brake can be used the electric motor of direct current in common performance. In this case by means of the setting of the machine of direct current or tested engine to bob platform the measurement of power can be produced on wattmeter with the approximate accuracy/precision within limits of 3-5o/o or by dynamometer with higher accuracy/precision within limits of 0.5-1o/o.

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On the schematic 10h in question is shown the unit of electric motor on bob platform with the beam balance measuring system of the torsional moment. The field of application of this unit is the same

as for those who were given it is above.

6. Electric brake units with electric motors of alternating current (Fig. 10i, j).

Unlike testing units examined above brake wide application as brakes found the common standard asynchronous and synchronous electric motors of alternating current. Furthermore, in these units enter hydraulic coupling, hydraulic transmission or hydraulic converter, designated:

a) for decrease and the smooth change in the speed of electric motor, which rotates at constant velocity, in its work in motoring for providing the start-up conditions or cold run-testing of tested engine;

b) for reduction/descent and alignment/levelling of speed on the necessary constant velocity of the rotation of electric motor, for operational provisions for its in generator mode, with regeneration, under conditions of braking tested engine.

As hydraulic coupling can be used the hydraulic transmissions

and the hydraulic converters, already mastered by industry, different types according to power, designation/purpose and with different nominal limits on the adjustable velocity. They begin to find wide application in industry and in the field of transportation [1].

FOOTNOTE [1]. At present hydraulic transmissions, mainly for diesel locomotives and for the drives of drilling rigs, are manufactured with the Kaluga and Murom Machine Building Plants. ENDFOOTNOTE.

Fig. 10i, shows standard electric brake unit with hydraulic coupling and electric motor of alternating current.

It should be noted that by similar units the surplus of power, lost in hydraulic coupling at the velocity of engine, which exceeds the necessary velocity of generator, is converted into the heat, which goes to heating of oil in clutch, which one should abstract/remove into the water-cooled, which circulates in water-oil radiators.

Power measurement of engine can be realize/accomplished either by applying the bob platform with dynamometer, or unit on the shaft between the engine also of the hydraulic transmissions of

dynamometric clutch for the measurement of the torsional moment.

On the indicated schematic the engine mount for an engine is arrange/located on bob platform with the trunnion, arrange/located of below center of engine. In this unit the electric motor easily is connected to the plant grid/network of alternating current without any converter devices.

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Units of such type can be applied for testing of different in power piston engines and gas turbines.

Fig. 10j, shows electric brake unit with magnetic slip coupling and the electric motor of alternating current.

Unlike testing unit examined above here instead of the hydraulic coupling for the transformation of the speed is used magnetic slip coupling as simpler in design and in the operation which is establish/installed between output shaft of engine and braking device.

On the given schematic during the rigid fastening of tested engine, the electric motor together with magnetic slip coupling is

establish/installed on bob platform.

7. Testing unit with induction brake (Fig. 10k).

Because of the great possibilities of induction brake, in producing of the necessary brake horsepower or velocity of rotation and obtaining necessary brake characteristic this stand of high-speed engines or engines with the large torsional moments on the low revolutions in a number of cases will be the only possible.

8. Combined brake testing unit (Fig. 101).

Of the combined units braking device consists of the hydraulic or induction brake, connected with the bob machine of direct current. This layout makes it possible to produce on stand launching/starting, warming up, cold rolling and removal/taking friction horsepower. With these operations hydraulic or induction brake runs free as flywheel; absorbed to them friction horsepower on the revclutions interesting can be determined previously. During engine, testing bob electric machine can work together with basic brake or be off. With datum to

layout for providing such works of the measuring system of the torsional moment for a basic brake and for a bob machine to more expedient have separate. The power-supply systems and connection to power systems and communications will be suchr as for installations with mentioned braking devices.

Besides the described above installations, intended for the different tests of various types of engines, they can find the wide acceptance and other types of installations. Thus, for instance, some motor vehicle plants of instead of complete tests for production engines are carried out only hot to breaking in without load on stands without the application/use of braking devices.

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The selective long-term tests of these engines are conducted in pilot plant on the arresters where with the selected engines completely are remove/taken all the necessary characteristics.

Simplified tests can be also carried out on the paired stands where the first engine undergoes cold rolling; its rotation is produced by the second engine which at this time undergoes heat tests under the load of the first. Then the first engine, passed cold rolling, is switched to tests, and in the place of the second engine,

is establish/installed following.

In each specific case the selection of the type of testing unit must be produced not only from type and construction of engine and its designation/purpose, but in many respects also it depends also on the state of technology of production, quality of finish and assembly.

§2. Testing units with regeneration.

In the majority of cases, the mechanical energy, developed with engine during its tests, by arresters is not usefully utilized. In air brakes it transfer/converts into movement and heating of air, while in hydraulic and induction brakes it is converted into thermal energy, in consequence of which them it is necessary to cool by running water.

In electric brakes where the mechanical energy, developed with engine, converted into electrical, usefully is not utilized, but it heads for the charging resistance where again it is converted into thermal energy.

Besides the use of mechanical energy, developed with tested engine, it is possible to also utilize heat of waste gases.

However, in connection with large capital investments and operational expenditure/consumptions, this is unprofitable.

As concerns the recuperation of mechanical energy by transformation by its braking device into electrical and as the possibility of its further use, problem has large national-economic value.

For using electric power, obtained from recuperation, in plant or district electric system the electric current must be variable, industrial voltage and frequencies.

In a number of cases this problem virtually can be solved for many enterprises of engine construction. It is especially expedient this to make on experimental stations of the series production where the general duration of the tests of each engine in its inherent work composes several dozen minutes or even hours, and also for the testing units where are carried out resource and other endurance tests.

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For the realization of recuperation, it is necessary, in order to:

a) brake was the electrical machine which in basic prolonged load mode/conditions worked as generator;

b) to ensure the possibility of the load of tested engine in the remaining modes of its operation, not encompassed by recuperation;

c) initial capital investments and operating costs for recuperation unit were economically justified.

On the possibility of use and selection of electric brakes with regeneration, it was said earlier. Here one should mention only about some specific special feature/peculiarities of this method.

For the selection of electric brake with recuperation, it is first of all necessary to examine the composition of tests and the operation of tested engine on all its mode/conditions on speed, duration of tests and the developed with it power in each mode/conditions.

Further one should establish/install, which mode/conditions it is expedient to utilize for recuperation. In all remaining mode/conditions must be provided the corresponding load of engine in accordance with technical specifications for testing. Sometimes it is sometimes expedient and possible to change some mode/conditions both according to the power and on the revolutions for the purpose of their use for recuperation.

On separate electric brake units, predicted for use with regeneration, it is necessary to consider following observations.

1. Units with synchronous or asynchronous electric motors with the transformation of velocity.

An expedient and economical schematic of testing unit with regeneration is the application/use as brake of a generator of synchronous either asynchronous electric motor with hydraulic coupling or magnetic slip coupling. The revolutions of this electric motor must be selected so that they would be somewhat lower than first continuous duty of the engine, working under load. Usually this corresponds to the

mode/conditions, which approach service power of engine. The power of electric motor taking into account its own losses and losses in slipping clutch must comprise approximately 70-80o/o of power of tested engine.

Indicated slipping clutches provide the preservation/retention/maintaining of the constancy of the rate of the rotation of the shaft of electric motor independent of a change in the revolutions of tested engine. In connection with the expansion of the field of application of hydraulic coupling up to 2000-3000 h.p. in power and above they can successfully be applied as slipping clutches. The efficiency of hydraulic coupling usually is approximately 0.80; furthermore, they have the prolonged service life of work. The field of application of electromagnetic couplings has already been noted above.

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Application/use at the units of synchronous or asynchronous electric motors in question from the number of in series made specimen/samples simplifies their acquisition, which considerably decreases initial capital investments. Furthermore, the connection of synchronous or asynchronous electric motors to plant electric system can be done directly, without any complex distributors.

As an example Fig. 11, gives the general view of experimental installation with regeneration for testing the diesels D-36. As brake-generator on this unit is accepted standard induction motor by the power of 20 kW, with rigid fastening by unit. Established/installed between the diesel and the electric motor magnetic slip coupling provides constant velocity on the shaft of electric motor. Here tested diesel is establish/installed on the bob frame whose suspension to the common/general/total frame of stand is realized with the aid of two cross-shaped bearings on elastic cell/elements (plates).

Power measurement of diesel is produced by the weight head effort/forces to which are transferred from bob frame by lever/crank system. This unit completely confirmed the positive qualities of the taken schematic.

2. Units with asynchronous electric motors without the transformation of velocity.

The use of induction motor with phase rotor at tested units with

regeneration is based on the principle of its possible operation in the generator mode when this electric motor they rotate at velocity, which exceeds synchronous speed.

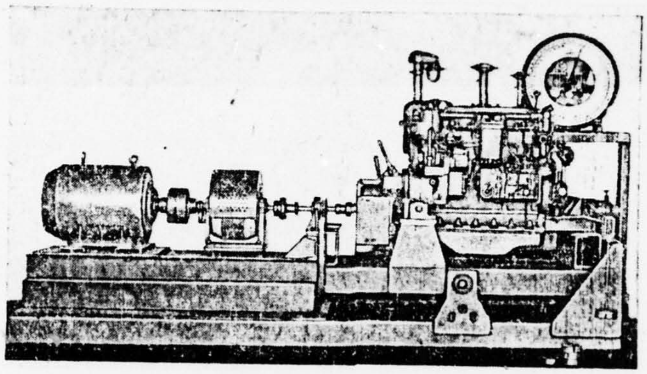

Fig. 11. Bob stand with magnetic slip coupling with regeneration.

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Similar units with direct drive, i.e., without the intermediate clutches or other velocity transducers, will be advisable in such a case, when the basic in duration charging mode/conditions of tested engine have relatively small differences on revolutions. In this case asynchronous electric motor is selected on velocity in such a way that it would correspond to the smallest revolutions of the first continuous duty of the tested engine, working under load. In this case,, kA and in all cases, for providing the generator mode of work the revolutions of asynchronous electric motor must be higher than it synchronous speed (not less than by 2-3o/o). With a further increase

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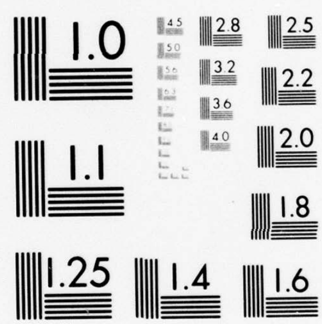

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in the revolutions of tested engine, the velocity of electric motor will be also raised; however, on strength it must not be above maximum permissible revolutions.

The control of the load of tested engine is produced by the resistance, included in the circuit of rotor. Besides that which was examined, are other schematics of the use of asynchronous machines for installations with regeneration; however, in view of their complexity and unwieldiness, they did not win acceptance.

3. Units with the machines of direct current.

Similar units can be successfully used for regeneration; however, they require the expensive converters and the corresponding areas for their arrangement/permutation.

The application/use of installations with regeneration in each individual case must be justified by the technical and economic calculations. During output useful to the used energy in the form of electric power into plant or transmission networks of alternating current its cost/value must be considered on the selling price of this area. For determining economic effect, must be taken into

account the losses in clutch, electrical machine and other losses, and also the operating costs and the difference in depreciation allowance in comparison with another equipment which it should be acquired without the application/use of recuperation. It is customary to assume that the recuperation is advisable with the complete compensability of all expenditures for 1.5 - 2 years.

[Page 42] Chapter IV.

TEST BENCHES AND MEASURING SYSTEMS.

§1. Types of the test benches for power measurement.

One of the basic and main parameters of thermopower engine during taking of its characteristics during tests is the determination of power. The measurement of the torsional moment from which is determined the power, can be done with the aid of the test benches, equipped with measuring systems. To the number of contemporary, basic requirements, presented to these systems, it is related:

a) the provision for the required accuracy of measurement;

b) convenience in the reading with the minimum expenditure of time and easy servicing;

c) the automatic balancing of the measured effort/force;

d) reliability and reliability, the stability of readings and finally system readiness for reading at any moment of tests.

Sometimes depending on the type of testing unit, its arrangement, character of tests and construction of tested engine, can arise other requirements. For example, the units, arrange/located in separate boxes, with the control, remote into the cabin/compartment of observation, require the arrangement/permutation of the indicator of measuring system (dynamometer) on control panel. The static effort/force, caused by the torsional moment, is not even during the short period of time constant value. Therefore oscillation/vibrations during a change in the static effort/force, and also the effort/force from engine vibrations must be damped by measurement system and they must not exceed the smallest scale division of displaying instrument. Measuring systems must not introduce the essential errors, coming out beyond the limits of the required accuracy of measurement during a change in the temperature of air, which can occur especially with the arrangement of installations in separate boxes and the considerable consumption of the air, which goes to the feeding of engine.

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The measurement of the torsional moment of the test engines can be produced on different stands one of the following methods:

first - with the aid of the bob suspension of the stator of braking device, which transmits the reaction of the torsional moment to measuring system;

second - the same, but with the aid of the setting up of entire brake on bob, dynamometric platform;

third - the same, but during the rigid setting up of braking device, and with setting up of tested engine on bob stand;

fourth - with the aid of dynamometric clutches and the bushings, called the torsion dynamometers.

For the production of the indicated methods of measurement of torque, respectively are applied the different types of the test benches.

1. Rigid stand with the bob suspension of the stator of brake.

On this type of stand, are carried out the measurements of the torsional moment using the first method, which is most widely used.

Here the rigid construction of the stand of engine is arranged with the bob suspension of the stator of brake, which provides the transmission of the effort/forces of the torsional moment. The schematics of testing units workers according to this principle, are depicted on Fig. 10f, g, h, i, j and l, and the general view of bob suspension with measuring system see in Fig. 4.

Bob suspension usually is provided for during the manufacture of all brakes, intended for testing units, and therefore it enters in the assembly of supply of braking device.

Structurally the balance suspension is realized in the form of the rocking in ball bearings stator, which is simultaneously the housing of braking device. Errors from the friction of stator in bearings and stuffing-boxs seal without taking into account of losses in measuring system are 0.1-0.3o/o of maximum value of the torsional

moment of this brake. Mainly they depend on the quality of the manufacture of suspension, selection of bearings, axial alignment, etc. The construction of stand itself for this type of installations is sufficiently simple and can be carried out as support/socket for a specific type of engine, or in the form of the general-purpose struts, giving the possibility of the adjustment of fastening places. The observance of the latter condition is necessary during successive testing one to unit of the different types of engines, but close between themselves in power, dimensions and weight.

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2. Rigid stand with the setting up of entire brake on dynamometric platform.

The measurement of the torsional moment of tested engine on this stand is produced using the second method which is similar to the first and differs from it only in the facts that it makes it possible as brake to utilize the different electrical machines in common performance whose stator does not have bob suspension. The latter here replaces the dynamometric platform to which is establish/installed common stationary electric motor.

The diagram of this installation is shown in Fig. 12. According to this diagram bob platform is suspend/hung from ball bearings and has an axle/axis of rocking, which coincides with the longitudinal axis of unit. For the purpose of provision by that necessary accuracy of power measurement on platform together with electric motor is establish/installed also magnetic slip coupling. The torsional moment of tested engine is transferred through the platform to lever/crank system and is measured by weight head.

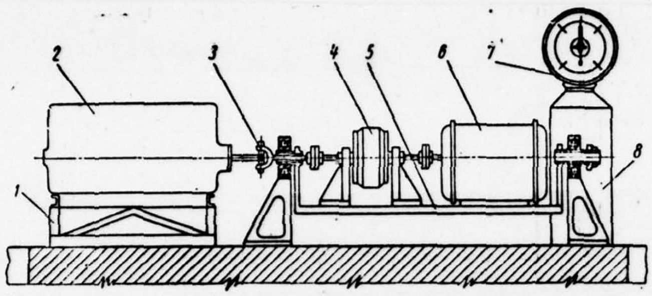

Fig. 12. Diagram of bob platform: 1 - stand-support/socket; 2 - engine; 3 - articulated coupling; 4 - magnetic slip coupling; 5 - bob platform; 6 - asynchronous electric motor; 7 - weight head; 8 - support/socket for weight head and leverage.

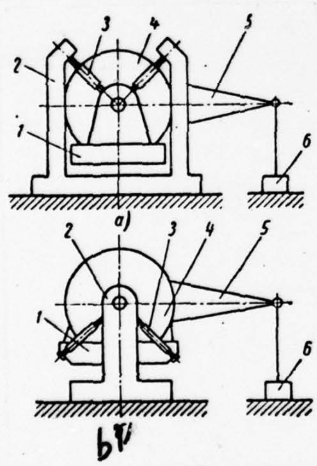

Fig. 13. Diagrams of bob suspension of platform with the aid of elastic hinge joints: a) with upper arrangement of rod-hinge joints; b) with lower arrangement of rod-hinge joints; 1 - bob platform; 2 - **strut for rods; 3 - rod-hinge joints (elastic cell/elements); 4 - electric motor; 5 - lever; 6 - dynamometer.**

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For the purpose of decrease in the friction sometimes, can be used bob devices with the rotating in bearing seats. In this case, the bearing obtains rotation from the special drive, for example, of electric motor. Such devices can be used for the measurement of the torsional moments of the low values at considerable angular deflections and large weight loads on the frame of bob platform.

Instead of the ball bearing supports the bob suspension of platform can be realized with the aid of elastic cell/elements. In this case the platform is hung to fixed struts on four rods, which have several milled planes, or on so many plates, the wide plane of which is parallel to the longitudinal axis of testing unit. This suspension provides platforms because of elastic deformation of plates. Since the rods or the plates of suspension work mainly on elongation with insignificant bend, a similar suspension is especially favorable during the low displacement/movement of platform and with large weight loads on it. Possible diagrams of such type of suspensions are shown in Fig. 13. As a result of the absence of bearings and the which is inherent in them friction, a similar suspension can ensure the high accuracy of the measurements of power

and it is simple in operation, since does not require lubrication, cleaning, etc. As a result of the fact that the plates have high exial stiffness, their longitudinal travel relative to testing unit are eliminated.

3. Bob stand with the rigid setting up of brake.

On this stand the measurement of the torsional moment of engine is produced using the third method when for any reasons it is not possible or expedient to accept the installation diagram, examine/considered using the second method.

Since from measuring point of view the second and third methods are equivalent, final selection of one of them will depend on the construction of stands and dynamometric platforms for these versions. It is necessary to keep in mind that with this device using the third method of measurement of the torsional moment it is required that the gas-discharge branch connections of piston engine or the gas-exhaust nozzle of the gas turbine, arrange/located on the one hand of engine, would not be placed in perpendicular plane with respect to the longitudinal axle/axis of engine. The nonobservance of this condition can cause essential errors to the accuracy of measurement of the

torsional moment a; a result of the effect of reaction from the outflow of waste gases with the indicated arrangement of branch connections. In order this to avoid, it is necessary to the gas-discharge branch connections of engine and nozzle of turbine to establish/install collector/receptacle in this direction that the outflow of waste gases would be in parallel to the longitudinal axis of engine.

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Fig. 14, shows diagram with bob suspension and the engine mount. For accessibility to tested engine, this frame is carried out in the form of a dynamometric platform, which rests on ball bearings or on cross-shaped hinge joints with elastic plates. The trunnion of platform below center of the shaft of engine. For providing the displacement/movement of platform, the communication conduit/manifolds, adequate/approaching the engine, can not have flexonics. In this case for providing their elastic deformation during platform they must be arrange/located in the plane, perpendicular to the longitudinal axis of stand, and have arms as the length of 1.5-2.0 m from the fixed point of the rigid fastening of tubes to of their attachment point of engine. The general view of testing unit with this bob platform for an engine is given in Fig. 15.

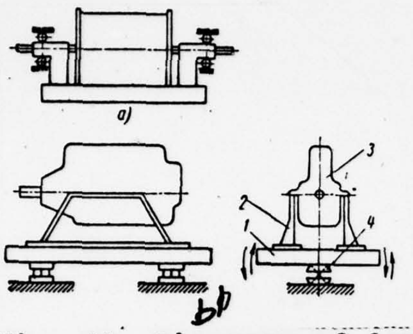

Fig. 14. Diagrams of dynamometric platforms: a) platform on ball bearings, trunnion coincides with axle/axis of engine; b) platform on cross-shaped hinge joints with elastic plates; trunnion of platform of below center of unit: 1 - platform; 2 - strut under engine; 3 - engine; 4 - cross-shaped hinge joint with elastic plates.

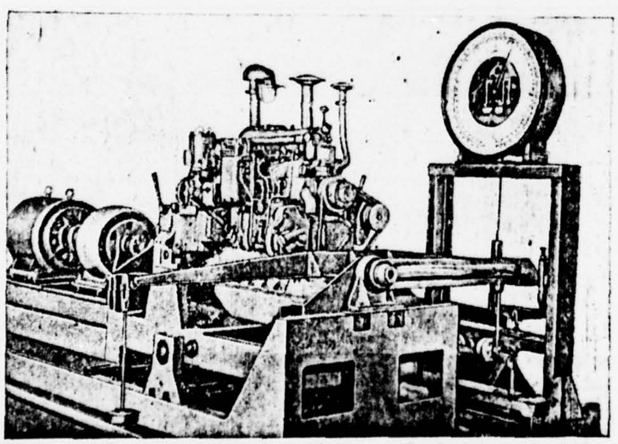

Fig. 15. General view of bob platform on cross-shaped hinge joints with elastic plates for engine D-36. Hinge joints are arrange/located from below platform.

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4. Stand with the torsion dynamometer.

On this stand of the measurement of the torsional moment, they are produced using the fourth method with the aid of the torsion dynamometers, which at present in practice thus far found insignificant application/use. In spite of the temptation of this method of measurement and the great variety of all possible constructions of dynamometric clutches and bushings until they win acceptance mainly due to the absence of the required accuracy/precision of measurement and absence of reliable specimen/samples for a continuous operation. Besides the low accuracy of measurement, which of some electrical pneumatic and hydraulic specimen/samples of clutches is located of 2-5o/o, there are also difficulties of their calibrations.

§2. Measuring systems of power.

The bench measuring system includes the devices: the receiving,

transmitting and showing or recording effort/force, transferred from the moving element of testing unit. Effort/forces to measuring system are transferred from the bob suspended/hung stator of brake or from the dynamometric platform of unit.

Measuring systems by the operating principle are distinguished cn:

1. Mechanical or beam balance, in which the measured effort/force, transferred by a system of levers to weight dynamometer, is balanced by the deflection of square or pendulum weight mechanism.

2. Hydraulic, in which transferred effort/force is absorbed by force gauge (by dynamometer), it is converted into pressure of liquid, measured by specimen or piston gauge.

3. Electrical, that convert transferred effort/force into electric pulse, received by measuring meter.

4. Other measuring systems, based on other operating principles. However, majority of them such, as pneumatic or torsion dynamometers, are located in the stage of laboratory finishing and therefore have not found practical application/use.

1. Mechanical measuring systems.

A greatest use for testing units find mechanical or beam balance dynamometers. In contemporary measuring systems of effort/force is reduced as the final result to the automatic balancing of the measured value by smaller known load. The force-measuring mechanism of this system can consist of: leverage, reversing mechanism, range mechanism and weighing device. Leverage converts effort/force from the moving element of installation and it transfers it to weighing device.

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Reversing mechanism is intended for the conversion of the alternating effort/forces of different directions into one direction. This mechanism is switched on in system as needed.

Range mechanism is the system of levers with the variable sense of arms and serves for more complete use of the scale of weighing device. Is intended it for an increase in the accuracy of the

measurement of different in the value effort/forces, for example low-power and high-powereds engine during testing at one and the same unit. Is switched on this mechanism in measuring system of necessity.

As the weighing device most of all, match up dial weight heads with quadrant mechanism. The balancing of the changing load occurs automatically by changing the arm of the load of the quadrant during its deflection, connected with the arrow/pointer of the weight head, which shows on the scale load change. The best constructions of weight heads have an error not more than 0.1o/o maximally strain which is recommended to have not more than 25 kgf with the course of the lever of head not more than 4-6 mm. With this accuracy/precision of weight head, its scale can have. 1000 divisions. The small load capacity of weight head and its slow speed make it possible to have a transmission with large multiplicity, thanks to which there will be assured the small displacement/movement of the moving element of testing unit. It is customary to assume that for achievement of the high accuracy of measurement, which on the indicated system as a whole can be reached by ±25o/o of the maximally measured effort/force, the displacement/movement of the moving element of the unit over the circumference of stator or over I repent dynamometric platform must not be more than 0.5 mm.

Leverage can consist of the levers of the first and second kind.

The value of decrease in the measured effort/force is determined by the relation of leverage from the formula

$$i_{общ} = \frac{q}{p}, \qquad (4)$$

where $i_{общ}$ is common/general/total gear ratio of leverage;

q - the load capacity of weight head in kg;

p - the measured effort/force on the arm of the moving element of the unit in kgf.

The value, reciprocal to gear ratio, he is called the multiplicity of the leverage:

$$K = \frac{1}{i}, \qquad (5)$$

where K - a multiplicity of leverage.

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during during operation of the stator of braking device or dynamometric platform, it occurs both the elastic and plastic deformation of the communications, conducted to these moving elements of the unit (metal tubes, electric wires, the rubber hoses and of so forth). The forces, which go to plastic deformation, with the amount

of this deformation strict law do not have. Therefore during large displacement/movements it should not be applied plastic materials for these supplying communications. Instead of them one should utilize the more elastic, although more rigid metal tube, effort/forces the spent on deformation which are considered during the calibrations of measuring system.

For decrease in the friction for the purpose of an increase in the accuracy of the measurements of an entire measuring system in supports and hinge joints of the leverage of reversive and range mechanisms, one should apply precision ball bearings, but is still better than the prism and elastic cell/elements in the form of plates and cross-shaped hinge joints.

Beam balance systems allow/assume the carrying out of weight head from the test bench and its arrangement/permutations in the cabin/compartment of control. This is necessary when the stay of the service personnel near unit is inadmissible. With carrying out weight head is furnished in box of observation window for convenience in visible reading according to the scale of head or they place directly in the cabin/compartment of control with the appropriate elongation of idler levers in the form of tube rods.

Mechanical measuring systems with weight head can successfully

be applied for the different weight fuel-metering devices, oil and other liquids, the accuracy of measurement on which can also reach ±0.25-0.35o/o of maximum weight of the measured liquid.

During the correctly selected constructions mechanical measuring systems are sufficiently simple, reliable and stable in operation.

2. Hydraulic measuring systems.

Along with beam balance dynamometers, wide application in Soviet and foreign experimental technology find also hydraulic measuring systems. Especially they are advisable for the measurement of large effort/forces during the small displacement/movement of the moving element of the platform of stand and when according to the conditions of arrangement/permutation recorder must be related by considerable distance (to 15-20 m). In hydraulic systems the primary instrument in which the measured effort/force is converted into the pressure of liquid, is force gauge (dynamometer). The force gauges of hydraulic systems can be flowing and non-flow type. In non-flow type dynamometers the measured effort/force is absorbed by closed volume of working fluid. The movement of piston (diaphragm/membrane) in these dynamometers is determined by the elasticity of system and can

compose siginficant value.

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The accuracy of the measurement of hydraulic system with non-flow dynamometers is determined mainly by the value of a change of the geometric dimensions of dynamometer and volume of liquid in system during a change in the ambient temperature. During temperature change not more than 5° C this accuracy/precision can be reached within limits from ±0.5 to +1.0o/o. Temperature changes in the environment on 20-40°C decrease the accuracy of measurement in non-flow systems to ±2.0-3.0o/o.

The flowing dynamometers to which they are related and dynamometer with microduct, are characterized by the presence of the duct of the liquid through their cavity. Therefore they are applied for the exception/elimination of the effect of a change in the volume of dynamometer and working fluid in the case of a change in the ambient temperature, and also the limitation (decrease) of piston stroke (diaphragm/membrane) of dynamometer. Such dynamometers require the device of the system of duct or additional feeding the value of circulation of which through the dynamometer is automatically regulated by piston stroke or by its valves depending on the value of the effort/force, which effects on dynamometer. So, with an increase

of the load on dynamometer pressure in its cavity it increases because of inflow or additional feeding of liquid, and during decrease in the load as a result of hydraulic slip - it falls.

the accuracy of the measurement of flowing hydraulic systems can be reached by ±0.2-0.3o/o.

For pressure measurement in the cavity of dynamometer as recorder, are commonly used for flowing systems piston manometers of class 0.1, for non-flow - specimen manometers of class 0.3.

For filling of hydraulic systems, are applied the alcohol glycerin mixtures, the transformer oil and other liquids.

3. Electrical measuring systems.

In electrical measuring systems as the sensor of electric pulse under the effect of load, are utilized the extensometer, the inductive and other sensors. Although these systems are more progressive, since more available they make it possible to automate recordings and the recording of readings, the level of their finishing on accuracy/precision thus far is still low and even for

the best specimen/samples it is located of 1-3o/o of maximally measured effort/force taking into account its dynamic loads. One should to assume that with finishing and increase in their accuracy/precision they must receive wide acceptance.

For testing and calibration of all measuring systems of the torsional moment, bob devices are equipped by calibration devices. Calibration is realize/accomplished with the aid of the artificial loading of the moving element of the unit, by imposition on arm of the determined length of the loads whose weight is known. It consists of successive imposition from 6 to 10 loads on rod or cup of calibration device and their subsequent unloading in reverse order. The readings of dynamometer during imposition and taking of each load are record/fixed. according to the data of these readings, is constructed the calibration graph on which it is produced the determination of the torsional moment during engine tests.

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§3. Systems of control and direction.

Testing units and their systems are equipped with

monitoring-measuring equipment and the controls, which make it possible to check and to control the process of engine testing. Monitoring-measuring equipment is necessary also for recording of readings of some parameters during taking of different running qualities of engines. The perfection of measuring systems and the quality of instruments to a considerable degree determine the correctness and the speed of the evaluation of the operation on testing unit.

A quantity of measured parameters of engine and their accuracy/precision are determined by technical specifications for testing. The character of these measurements is dictated by both the requirements for systems themselves and by the indicated conditions for testing.

Depending on these requirements, the displays and measurement can be indicating, registering, and recording. In certain cases a quantity of measured points is sufficiently greatly, and taking readings and their recording they require considerable time. Therefore tendency toward the automation of these works, including recording, processing and obtaining ready printed record sheet with the indication of all necessary data, which characterize the engine operation under the separate conditions, is a task completely contemporary, necessary and solved. Below given the description of

the possible solution of this problem (see Chapter XI).

Basic monitoring instruments together with the controls and starting/launching are placed on the center section of the control panel besides basic, technological panel, there can be others, auxiliary, for example: the panel for electrical equipment and recording instruments and fuel-oil board of measuring equipment for power-supply systems, which makes it possible to improve the operation and to raise fire safety of testing unit. Control panels must be sufficiently compact and have the clear arrangement of instruments, make it is convenient to conduct control and observation of the engine operation on stand.

Remote control of the adjustable fittings of the systems of the maintenance of feeding one should realize/accomplish with the aid of electric drives with knob control from panel. The sectors of the fuel-feed control one should apply hydraulic, that obtained wide acceptance, that are characterized by reliability and convenience in operation.

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Chapter V.

POWER-SUPPLY SYSTEMS AND MAINTENANCE OF TESTING UNITS.

§1. Fuel systems.

The fuel systems of testing units are intended for the feeding of engines by fuels during the provision:

a) normal, uninterrupted and continuous firing;

b) the production of a precise measurement of the fuel consumption;

c) fire safety.

The most advanced and safe method of fuel feed to experimental

station is the system of the centralized supply from expenditure storage on conduit/manifolds.

These fuel lines are divided into the external, underground, relating to industrial mains enterprises, and internal, bench.

A quantity of external fuel pipes is determined from the number of types of the fuel/propellant, consumed by different testing units. The section/cuts of conduit/manifolds are determined from the maximum consumption of fuel/propellant and average most economical rated speed of flow. For bright light/lung oil-products this speed one should accept not above 1.5 m/s. Besides basic propellant, sometimes can be met the need for feeding the starting fuel/propellant for which in this case also is provided for separate fuel pipe.

Besides the supplying distributing conduit/manifolds, it is necessary to provide for one discharge lead for the drainage of fuel/propellant during the calibration of flow meters or in the emergency cases. For the procedure of this fuel/propellant of experimental station (outside the building) or in storage itself must be provided for the capacitance/capacity, intended only for these purposes. The size/dimension of this drainage cistern must be not the less the total capacitance of all bench fuel fuel systems, including conduit/manifolds, fittings and their measuring meters.

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The packing of main-line fuel pipes within experimental station is not recommended. It is expedient to furnish them outside building, underground, of in parallel to the front testing units. Input/introductions of fuel pipes into experimental station is done by taps from external main-line fuel pipes to each testing unit separately.

Fuel feed to testing units is produced by the pumps of fuel reservoir or by means of its extrusion from the fuel tanks by the compressed air. The first method is more preferable, since it is safer in operation and does not require the application/use of cisterns of the increased strength, workers under pressure, but main that that the supplied fuel/propellant will not contain the air bubbles, which sometimes penetrate in it under the effect of diffusion with contact. For the overcoming of hydraulic pressure drag, in the fuel/propellant of the feed pipe must be somewhat higher than required backwater of fuel/propellant at the entry into bench system. This it frees from the need for switching on in bench systems the additional booster pumps.

Fig. 16, shows the diagram of the system of the centralized fuel supply of experimental station, while in Fig. 17 its general view. The fuel/propellant, supplied to the drainage front of storage in the railroad tank cars (or by motor transport), by scavenge pump is drawn off into the cisterns of fuel reservoir. By another pressure pump is realize/accomplished the continuous feed of fuel/propellant during operation of the testing units of station on forcing main conduit.

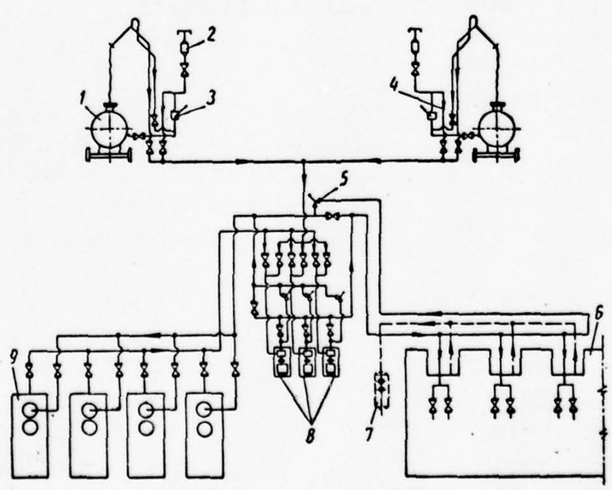

Fig. 16. Schematic diagram of centralized fuel supply of

experimental station: 1 - railroad tank car for fuel/propellant; 2 - fire in front of keeper; 3 - hand pump for filling of transfer pump; 4 - drainage column (on pier); 5 - check valve; 6 - experimental station; 7 - cistern of fuel jettisoning from bench systems; 8 - pumps for plum and fuel feeds; 9 - cistern of fuel reservoir.

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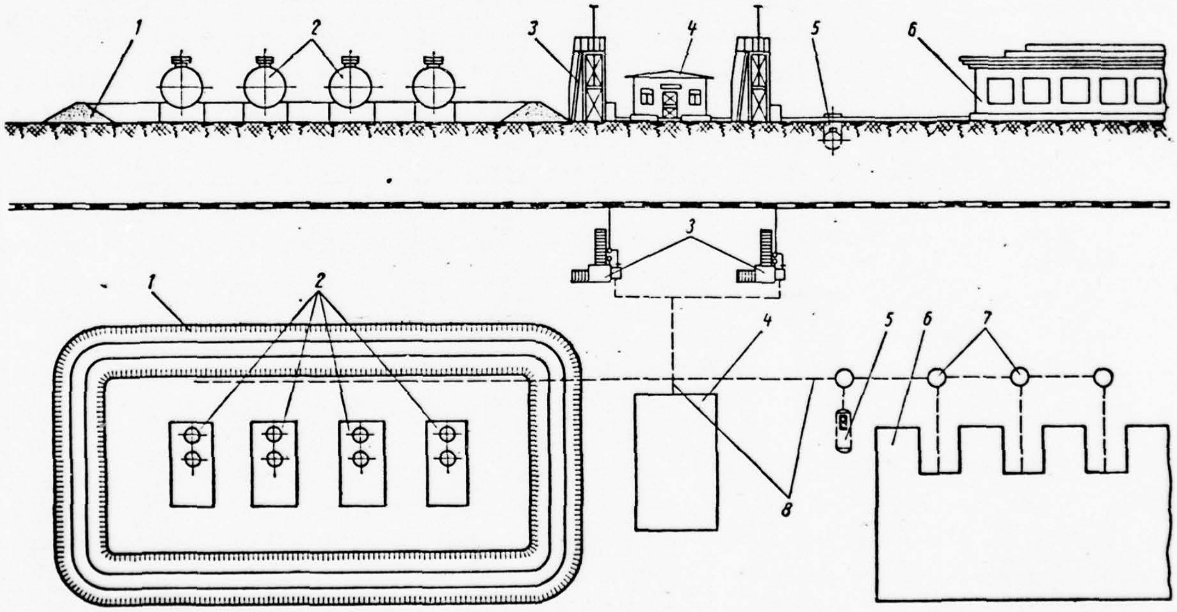

Fig. 17. General view of system of centralized fuel supply. 1 - earth shielding shaft; 2 - cistern of fuel reservoir; 3 - stations for fuel

dumping from the railroad tank cars; 4 - pumproom; 5 - cistern of the emergency discharge (underground); 6 - experimental station; 7 - manholes; 8 - route of fuel pipes (underground).

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The excess of subject fuel/propellant is drawn off into cistern on return line. In open type fuel reservoirs with the ground-based arrangement of cisterns, pumping is furnished in closed location.

With the arrangement of testing units in the common/general/total hall of pipelines, which go within the building of experimental station, they must be arrange/located in the channels, charged after their installation by dry sand. For the installations, arrange/located in the isolated/insulated boxes, the fuel lines in them or indoor of technological equipment under the cabin/compartment of control and in cabin/compartment itself can be furnished in closed slots and along the walls of these locations. These channels also must be filled by dry sand.

Each supply of fuel pipes to bench testing unit must conclude with header with the aid of which the fuel feed can be connected to the necessary type of fuel/propellant.

All external and internal bench fuel lines must be packed with gradient/draft to the side of power supply. The minimum gradient/draft of fuel pipes within experimental station is establish/installed within limits of i = 0.01-0.005, but for external conduit/manifolds this gradient/draft must be not less than i = 0.002.

The distributing fuel pipe of basic propellant on section from collector/receptacle to tested engine must be equipped with the following minimally necessary equipment, arrange/located in the given below sequence:

a) coarse filter;

b) total flow meter;

c) pressure regulator;

d) device for the measurement of the specific fuel consumption;

e) fine filter;

f) fire valve/gate (valve).

Fig. 18 as an example, gives the schematic diagram of the fuel system of the unit, intended for testing the gas turbine. This diagram is suitable also for testing the piston internal combustion engines. Fuel equipment is arrange/located in sequence indicated above and has remote control. The operational procedure of this system does not require explanations.

For the installations, arrange/located in common/general/total hall, if control panel is arrange/located next to unit, control of the locking, emergency, gauging and metering equipment can be realize/accomplished directly. For the installations, placed in separate boxes with the isolated/insulated cabin/compartment of control, this control is recommended to produce only remotely, from contrpl panel.

The pressure constancy of fuel/propellant in bench system is achieved by the setting up of pressure regulator, which is adjusted to the necessary overpressure.

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The construction of the close fitting valve of the systems of

fuel feed must eliminate overflowing or leakage of fuel/propellant. Entire/all fittings and the equipment, equipped with device for the draining of fuel/propellant or air exhaust, must be abstract/removed into drainage fuel pipe. The free end of the latter must be derived in the atmosphere on the height/altitude, which exceeds the highest point of the level of the drained fuel/propellant, and equipped with air vent with fire safety device/fuse.

For the measurement of the fuel consumption, can be used the instruments and equipment, the based on different methods measurements.

Comparative data on the accuracy/precision of the measurement of the fuel consumption by the most commonly used methods and instruments are given in Table 3.

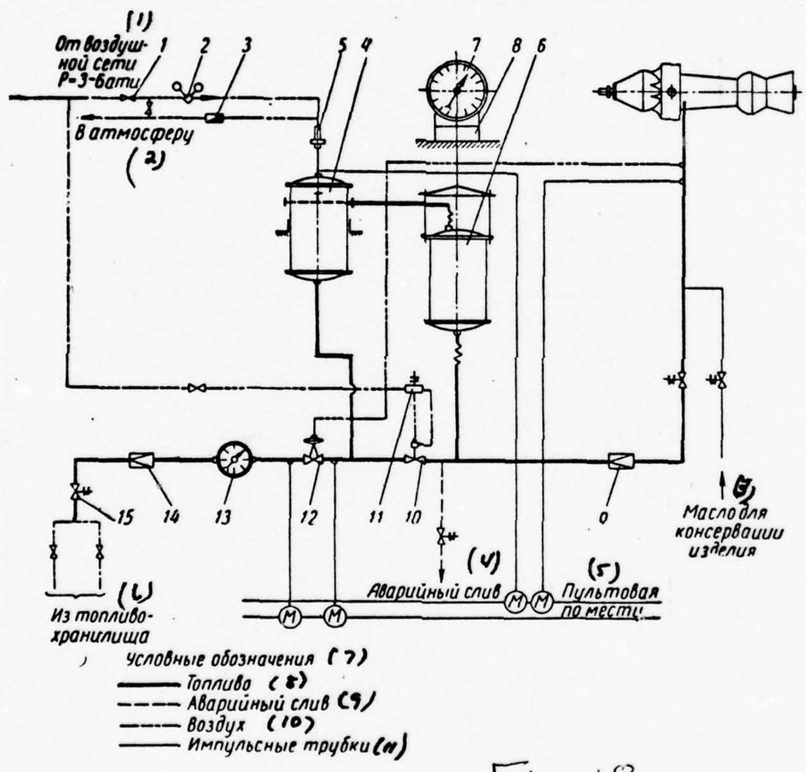
(1)
От воздушной сети P-3-6ати
1
2
3
5
4
7
8
6
В атмосферу
(2)
15
14
13
12
11
10
9
(3)
Масло для консервации изделия
(4)
Аварийный слив
(5)
Пультовая по месту
(6)
Из топливохранилища
Условные обозначения (7)
Топливо (8)
Аварийный слив (9)
Воздух (10)
Импульсные трубки (11)

Fig. 18.

Fig. 18. Schematic diagram of fuel system for testing gas turbine: 1 - valve/gate locking; 2 - pressure reducer of air; 3 - air filter; 4 - tank compensating; 5 - air vent; 6 - tank of weight measurement of fuel consumption; 7 - weight head; 8 - lever/crank reducer; 9 - fine filter; 10 - pneudraulic valve; 11 - pneumatic actuator of valve; 12 - pneumatic valve gauging; 13 - total counter; 14 - coarse filter; 15 - valve with electric control.

Key: (1). From air line; P = 3-6 atm(gage). (2). To the atmosphere. (3). Oil for storage of article. (4). The emergency discharge. (5). Console on place. (6). From fuel reservoir. (7). the conventional designations. (8). fuel/propellant. (9). the emergency discharge. (10). air. (11). Pulse tubes.

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From them widest use was received:

a) for total consumption and the account of fuel/propellant - volumetric, mechanical flow meters of the type SVSh, manufactured by the plant "Lenpribor";

b) for the specific measurement of the fuel consumption - the weight flow meters of different constructions and volumetric flow meters of the type "fuel meter".

Table 3. Comparative the data of the accuracy/precisions of the measurement of the fuel consumption by different methods and instruments.

(1) Способы и приборы измерения	(2) Назначение	(3) Точность измерения в %
I. Весовой способ (4)		
Автоматический весовой расходомер (5)	(6) Для измерения удельного расхода топлива	0,2—0,3
Весовой расходомер с ручным управлением (7)	(8) То же	0,3—0,5
II. Объемный способ (9)		
Мерные колбы (10)	»	0,6—1,0
Штихпробер (11)	»	0,4—0,6
Объемные механические расходомеры типа СВШ и другие (12)	(13) Для суммарного расхода топлива	0,5

Key: (1). Methods and the instruments of measurement. (2). Designation/purpose. (3). Accuracy of measurement in o/o. (4). Weight method. (5). Automatic weight flow meter. (6). For the measurement of the specific fuel consumption. (7). Weight flow meter with manual control. (8). The same. (9). Volumetric method. (10). Measuring flasks. (11). Fuel meter. (12). Volumetric mechanical flow meters of the type SVSh and others. (13). For total propellant construction.

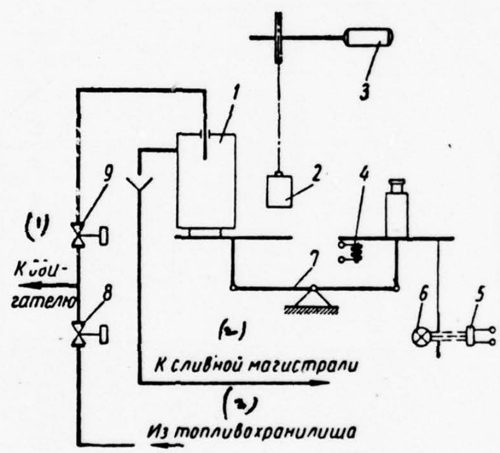

Fig. 19. Schematic diagram of automatic fuel-metering device: 1 - small tank for fuel/propellant; 2 - weights; 3 - electric motor; 4 - electromagnet; 5 - photocell; 6 - illuminating tube; 7 - cup weights; 8 and 9 - rapid-action valves with remote control.

Key: (1). To motor. (2). To the drain line. (3). From fuel storage.

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Fig. 19, depicts the schematic diagram of automatic weight flow meter, developed by workers of NAMI, while in Fig. 20 - its general view. This flow meter is simple by construction, it is convenient and reliable in work. The consumption in it is determined from the time of consumption/production/generation, previcusly known fuel load. Are applied two operating modes: without the measurement of consumption and with the measurement of the fuel consumption. In the run of job when the measurement of flow rate is not produced, engine feeds from the conduit/manifold, connected with fuel reservoir. In this case valve 9 is opened, and valve 8 is closed.

Small tank 1 in this case is completely filled. Control of filling of small tank is produced with the aid of photocell 5. With the illuminations of photocell is open/disclosed valve 9 and is switched on electromagnet 4; with the blackout of photocell, is closed valve 9 and is de-energized electromagnet 4.

Before measurement valve 8 is opened, and valve 9 is closed. Small tank 1 is completely filled, to which testifies the blackout of photocell. With pushing of knob, the "measurement" valve 8 is closed, and valve 9 is open/disclosed, as a result of which into engine begins to enter fuel/propellant from small tank 1. After the

consumption/production/generation of a small quantity of fuel/propellant, the weights get into equilibrium, photocell again it is illuminated and gives the signal.

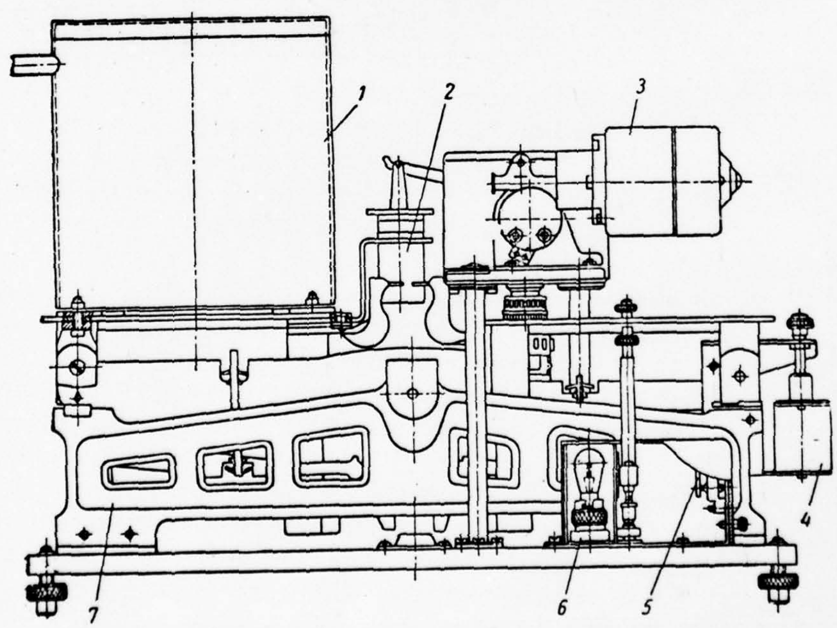

Fig. 20. General view of automatic fuel-metering device: 1 - small

tank for fuel/propellant; 2 - weight; 3 - electric motor; 4 - electromagnet; 5 - photocell; 6 - tube illuminating; 7 - weights cup.

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In this case, electric motor 3 lowers set of weights 2 to the balance pan with small tank, which droops. After the consumption of fuel/propellant, equal in weight to weight 2, the weights again get into equilibrium and is measured the time, spent to the consumption/production/generation of the measured quantity of fuel/propellant. At equilibrium the photocell again sends the signal by which electric motor 3 builds up weight 2, in consequence of which valve 9 is closed, and valve 8 is open/disclosed. Before the following measurement the small tank again is filled.

Sometimes bench fuel systems, besides weight or volumetric flow meters, are supplemented by the unit of the rotameter which gives the representation of value and character of the fuel consumption at any time of the operation.

The capacitance/capacity of volumetric glasses of fuel meter either service tanks of weight flow meters is determined from the formula

$$V = \frac{G_T t}{\gamma \cdot 3600} \qquad (6)$$

where V is the capacity of volumetric glass of fuel meter or service tank of weight flow meter in l;

$G_т$ is a fuel consumption by engine in kg/h;

t - time from beginning to the end of the reading, i.e., the duration of measurement in s. This time should accept within limits from 20 to 40 s;

γ - specific gravity of fuel in kg/l.

For gas turbines and the piston engines, working with the direct fuel injection, large value has a quality of filtration. To avoid the blockage of injectors or damage of the plungers of the fuel high-pressure pumps, manufactured with very high accuracy/precision, some types of these engines require so that the mechanical impurities in the fuel/propellant will be trapped by fine filter are not more than 5-10 μ in diameter. In connection with the fact that the gauze filters even with extra-fine grid cannot hold such particles, while in felt and different cloth filters occurs precipitation of separate filaments, recently wide application find paper filters. In them as the filtering cell/element, they are applied: the specially machined

porous paper pulp or paper tape impregnated with special resins for imparting to it the strength in wet form and the determined filter discrimination. Fig. 21, shows this filter of the English firm SAU of corporation Lukas, who according to her data filters particles no larger than 1-3 μ.

Application/use in the bench systems of fuel fine filters contributes to an improvement in the quality of work of the engines of series production and frequently it is extremely necessary with the experimental finishing of engines in research laboratories.

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The throughput capacity of main-line distributing conduit/manifold is determined by the hourly consumption of the fuel/propellant, consumed by experimental station, from the following equation:

$$G_{сумм} = G_{т} n \eta K_{одн} \text{ the kg/h} \quad (7)$$

where $G_{сумм}$ is total consumption of fuel/propellant by all, simultaneously working testing units, or the throughput capacity of main conduit, in kg/h;

G_T - the fuel consumption by one testing unit at the nominal power of engine in kg/h;

n - total number of test installations;

η - the coefficient of average load of engine according to power for the time of its all tests. In the majority of cases $\eta=0{,}5-$ $-0{,}8$ from the nominal power of engine, which approximately corresponds to the same shortening in the fuel consumption;

$K_{одн}$ - the diversity factor of work of testing units. This coefficient is defined as

$$K_{одн}=\frac{T_1 c_{рас} K_н}{T_2 c_{прин}}, \quad (8)$$

where T_1 - the duration of the operation on unit (stand) for the time of all its tests, or the so-called operating time of engine on to gas, in h;

$c_{рас}$ is a quantity of stands, which require according to calculation;

$K_н$ - the variation factor of stand operations, which considers the most adverse agreements of work of several installations and possible jerky feed of engines to experimental station. The value of this coefficient should accept within the limits $K_н=$ 1.10-1.20;

T_2 - the general labor consumption of bench works as the time of all tests of engine in machine-hours;

$c_{прин}$ - a quantity of taken stands.

Note. With a quantity of stands less than four product of the number of stands n by diversity factor $K_{одн}$ in formula (7) one should round to integer to large side.

If experimental station contains stands for the engines of different power, the throughput capacity of main conduit one should determine according to each group of stands separately with the subsequent summation of the obtained results.

At discharge velocity indicated above, hydraulic losses from friction on the direct/straight sections of conduit/manifolds for bright oil-products are 0.01-0.025 m H_2O on 1 lin. m. of conduit/manifold.

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In bench fuel systems common/general/total hydraulic losses taking into account all local resistance, including the resistance in fittings and equipment, they are from 7 to 12 m water column. If

necessary of obtaining the more precise values all of their these resistance one should determine by hydraulic design according to the procedure, presented in §7 of Chapter V.

All fuel lines can be manufactured from the steel seamless pipes of general purpose or from petroleum-gas-water-conducting tubes. Fuel lines up to 50 mm in diameter should be assembled with the aid of threaded connections, but for diameters above 50 mm - a way of flange joints. Quantity of connections in fuel pipes should be minimum, but sufficient for the periodic joint of system. The permanent connections of fuel pipes are produced into joint, by welding by good-quality electrodes.

As sealing material in the places of the packing/seal of the connections of fuel pipes and fittings, are applied gas and petroleum stable materials: vinyl chloride, sovprene and other plastics. With the connection of fuel pipe to engine for convenience in installation and extinguishing of vibration it is expedient to produce with the aid of flexonics in the form of the flexible hoses of the type of Superflex, durite hose/pipes and gasoline-resistant clutches, hose/pipes of braiding construction, but for high pressures - elastic metallic hose/pipes made of the seamless corrugated brass tubes.

The selected on the visual inspection tubes must be before the

installation decontaminated from contamination and scale. Cleaning tubes is produced mechanically or by hand with the aid of wire brushes to metallic luster. After purification/cleaning the internal surface of tubes is washed with an antirust solution or kerosene and is sweat/dried.

The external surface of tubes also is cleaned of dirt and scale, after which they are welded into component/links along 3-4 tubes. The welded joints of tubes are tapped by hammer, and through each component/link is run 2 times wire brush for descaling of tube in the places of the welded joints.

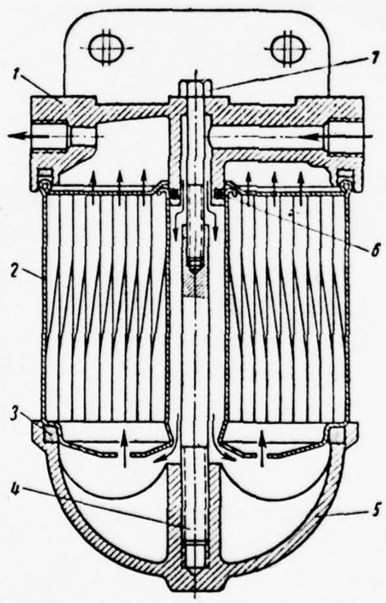

Fig. 21. Fine filter of fuel/propellant with paper filtering cell/element: 1 - head of filter; 2 - filtering element; 3 - ferrule; 4 - connecting rod; 5 - cap/cover of filter; 6 - ferrule; 7 - bolting together.

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After welding and installation, the conduit/manifolds and entire system as a whole are tested for strength with hydraulic pressure, but on density - by pneumatic pressure. The value of these pressures and the holding time are determined depending on the operating pressure of system from the norms of Gosgortekhnadzor [99sp15 - State Committee of the Council of Ministers for Supervision of Industrial Safety and for Mining Inspection (RSFSR)].

The seal of the connections of the welds of tubes, of close fitting valve and connections to equipment with the filling of them with the compressed air is checked by means of smearing by their soap solution.

All conduit/manifolds, cisterns, the drainage tanks etcetera the equipment, sunk into the earth/ground, must have protective coatings from the corrosive effect of the surrounding soil.

Before the imposition of protective coatings, the conduit/manifolds, cisterns, tanks etcetera equipment preliminarily must be tested to strength and density and are decontaminated from

contamination, scale and rust to metallic luster. As protective coating can be used the following bituminous mixtures, applied in three layers:

a) the first layer, as priming, will be applied in cold state, consists it of two parts by the weight of the paraffin tar, one part of benzene and four parts of the gasoline of the second type;

b) the second and third coverings are bituminous mixture 85o/o, splitta of bitumen No 3, three parts of bitumen No 5 and 15o/o of kaolin or asbestos dust. Bituminous mixture will be applied in hot state. The third layer will be applied after the cooling of the second layer.

§2. Oil systems.

Of the majority of the engines of lubrication system, they are fulfilled with the closed system of circulation. In transport engines oil cooling is produced by air flow during the motion of machine or by the special setting up of fan. In other engines this cooling is realize/accomplished in heat exchangers - radiators - air flow or water. During bench tests when engine is located in fixed position, for oil cooling in the majority of cases, it is necessary to resort to bench radiators. Furthermore, during the test work of engines it

is necessary to ensure monitoring of work of the system of lubrication and to simultaneously produce the determination of the consumption of oil.

Therefore testing units usually into the lubrication system of engine.

For the majority of installations, bench oil systems are provided for individual, and sometimes when it is not required to conduct the measurement of the consumption of cil of the tested engines, such systems can be common for the group of stands or for an entire experimental station.

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The oil supply of testing units and the return of waste oil can be realize/accomplished centralized or with the aid of intrashop and interdepartmental conveying devices.

The centralized oil feed is realize/accomplished with the aid of pump on the oil line, which connects oil storage with the expenditure capacitance/capacity of experimental station. For each type of oil, one should establish/install separately one feeding and one discharge leads, the latter is simultaneously the conduit/manifold of the

emergency discharge. The centralized oil system is advisable with the consumption not less than 1-1.5 t into replacement. The conduit/manifolds of the centralized oil supply are laid in channel together with their warming steam line which must be included into common/general/total with them thermal insulation. All oil lines must be packed with gradient/draft to the side of power supply. Minimum gradient/draft within the limits of experimental station must be not less than 0.01, and of external main-line oil lines it is not less than 0.003.

In the case of the delivery/procurement of oil on butter storage with the aid of mobile conveying devices in flanks with experimental station, one should provide for oil room where must be produced preheating, storage and distribution of oil on units.

Depending on the consumption of oil, this distribution can be organized both in the small tare on trucks or electric cars and on special conduit/manifolds; distribution on oil line will be advisable with the consumption of oil not less than this was shown above.

In certain cases can be provided for the closed circulation oil system for several testing units.

The basic equipment of this system, which consists of

expenditure oil tank with the preheating of oil, centrifuge or pressure filter for purification/cleaning of oil, pump and drainage oil tank are usually furnished in basement or in specially separated oil room under the condition of providing the possibility of the drainage of oil from the feeding and drain conduit/manifolds, laid in channel. The wide application of the closed circulation oil system is limited to the absence of possibility to conduct the measurement of the consumption of oil with the required accuracy/precision in each engine, which passes testing, to check the circulation of oil at each unit and to change the temperature conditions of the lubrication system of separately each engine.

These shortcomings are deprived the individual systems of oil supply with separate oil feed for each testing unit.

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Such of system they must be equipped with equipment and the equipment, arrange/located in the direction of oil outlet from engine in the following direction:

1) the signal indicator of the detection of shaving (for the engines whose crankshaft has slide bearings);

2) filter oil;

3) the radiator of oil cooling;

4) the indicator of the course of oil;

5) upper expansion oil tank with foam separator;

6) expenditure, measured oil tank or the aggregate/unit of the weight flow rate of oil;

7) filter is oil.

Sometimes on the scavenge pipe before the filter, is establish/installed reduction bypass valve for a preservation from the destruction of the filtering cell/elements and radiator with the increased oil pressure in the case of the possible circulation of oil not heated through through the filter. In this case the tightening of the spring of reduction valve must ensure the bypass of oil at a pressure before the filter and the radiator not higher than permissible.

To avoid the launch opportunity of engine with the closed tap/crane of oil feed, is provided for its blocking with the ignition system of engine or the starting/launching rack of fuel pump.

The drainage of surplus oil, which enters from assemblies and oil system as a whole, one should produce into drainage system or through the drainage emergency oil line into the drainage tank of waste oil.

In the places of possible air lock for the non-admission of the formation of air locks, the lubrication system must be equipped with atmospheric tap/cranes or automatic air vents.

The schematic diagram of bench oil system, comprised in connection with the tests of gas turbines, is given in Fig. 22.

Basic initial value for determining the diameter of conduit/manifolds and calculation of the hydraulic resistance of oil system is the circulation of oil. The latter depends on the construction of engine and it must be assigned/prescribed by technical specifications. In the absence of these data pumping of oil in the system of engine or in bench oil system $G_м$ it can be determined by the formula

$$G_м = \frac{Q_м}{c_м \gamma_м \Delta t \cdot 60} \text{ l/min} \quad (9)$$

where $Q_м$ is a heat emission into oil in kcal/h;

$c_м$ - the heat capacity of oil; during with sufficient accuracy/precision for all mineral oils, it is possible to accept $c_м = 0.5$ kcal/kg;

$\gamma_м$ - specific gravity/weight; it is possible to accept $\gamma_м = 0.9$ kg/l;

Δt - a difference in the temperatures of oil at output/yield and the engine inlet in °C.

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Heat emission into oil $Q_м$ is accepted according to the technical specifications of engine. It can be also determined from the equation

$$Q_м = G_т H_u k \text{ kcal/h} \quad (10)$$

where $G_т$ - the hourly consumption of the fuel/propellant, expended by engine, in kg/h;

H_u - fuel heating value in kcal/kg;

k - the coefficient, which considers heat emission into oil from entire heat, introduced into engine. Approximately this heat emission for all types of piston engines is approximately 1o/o, i.e., $k\approx$ of 0.01, and for gas turbines it is possible to approximately accept $k\approx$ 0.002.

A difference in the temperatures of oil at output/yield and the engine inlet for piston engines is 30-40°C, also, for gas turbines from 40 to 50°C.

For the purpose of decrease in the hydraulic resistance in bench oil system, the feed rate of oil in conduit/manifolds one ought not to accept above 1-1.5 m/s. Circulation oil line, in particular on the section of the suction line, must be as far as possible shorter and more direct/straight, without sharp rotations and the transfer/transitions of section/cuts.

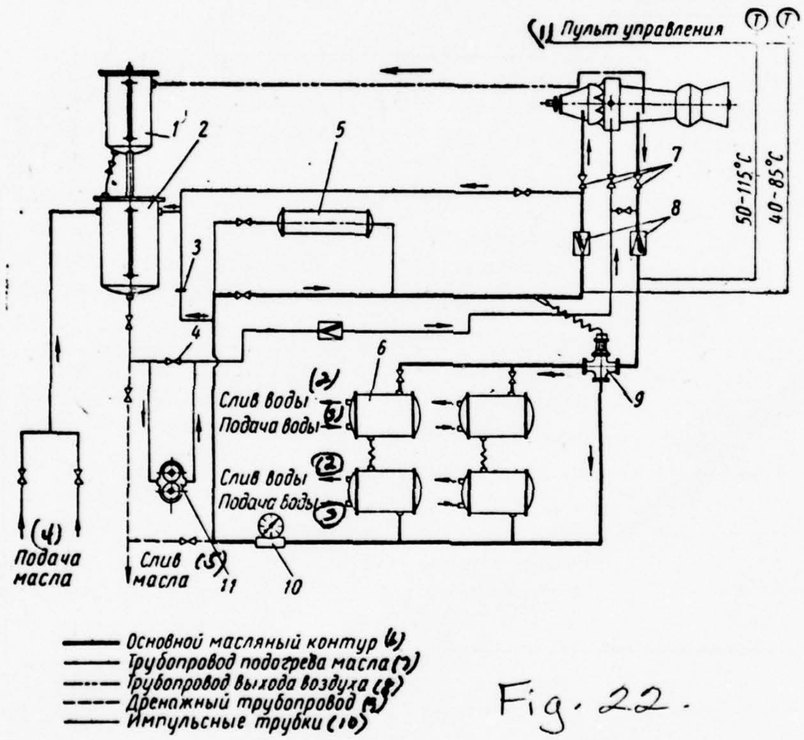
(1) Пульт управления
1
2
5
3
4
6
7
8
9
10
11
50-115°C
40-85°C
(2) Слив воды
(3) Подача воды
(2) Слив воды
(3) Подача воды
(4) Подача масла
(5) Слив масла
Основной масляный контур (6)
Трубопровод подогрева масла (7)
Трубопровод выхода воздуха (8)
Дренажный трубопровод (9)
Импульсные трубки (10)

Fig. 22.

Fig. 22. Schematic diagram of bench oil system for testing gas turbines: 1 - upper oil tank with foam separator; 2 - service tank; 3 - discharging jet; 4 - check valve; 5 - flowing electric heater; 6 - radiator; 7 - shutoff valves; 8 - filter; 9 - temperature controller of type RTPD-80; 10 - flow meter of type SVSh; 11 - pumping unit.

Key: (1). Control board. (2). Drain of water. (3). Water supply. (4). Oil feed. (5). Oil drain. (6). Basic oil outline/contour. (7). Pipeline of the preheating of oil. (8). Conduit/manifold of air outlet. (9). Drainage line. (10). Pulse tubes.

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The local resistance of this section must be minimal. The diameters of the suction and evacuating sections of system one should accept identical. The construction of filter at oil outlet from engine must provide the possibility of convenient and rapid inspection and its purification/cleaning. Is recommended the application/use of the dual filters which make it possible to produce this switching for control during engine testing without stop.

For purification/cleaning of oil can be applied the filters of the different types: mesh, felt, fabric, paper and others. Widest use received gauze filters.

For the plum of waste oil from an entire oil system, and also for the emergency discharge of oil the system must be equipped with the drainage oil tank, which ensures the possibility of the self-flowing drain in it of oil.

Expenditure and drainage oil tanks are supplied with steam or more convenient in operation by the electrical tubular preheating devices.

For providing the normal operation of engine, bench individual oil systems must be equipped with foam separator. Most effectively foam separator works on hot oil, and therefore it one should establish/install in upper receiving oil tank, in the scavenge pipe, before the cooling radiators. One should apply foam separator with tangential oil supply into the housing of the foam separator which is furnished above the highest oil level of upper oil tank with the filtration of oil through the grid.

The filtering grid of foam separator must be applied from brass grid with 500-700 cells on 1 cm^2. To each liter of the circulation of oil per minute, one should accept 10-15 cm^2 of this grid.

The measurement of circulation or consumption of oil can be produced with volumetric or weight method. The accuracy/precision of measurement by volumetric method cannot be reached more than 0.5-1.0o/o, whereas weight it can be obtained by 0.2-0.3o/o. For weight measurement can be used the assembly, similar fuel, described above, or the weight flow meters of other constructions.

Radiators or heat exchangers for oil cooling by water are establish/installed on the scavenge pipe of bench oil system. If necessary for the unit of several radiators, the latter are installed according to the pattern of parallel or series connection. The pattern of parallel connection of radiator gives greater conveniences in operation and smaller hydraulic resistance, but it requires large heat-transfer area. In practice larger propagation received these diagrams as more maneuverable and more reliable.

The temperature constancy of oil is reached by the quantitative control of oil, which goes across the radiator and besides it, by means of further mixing with cold oil or by flow control of cooling water in radiator.

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The temperature control of oil should realize/accomplish

automatically with the aid of a temperature controller of the type RTPD-80 or by other means. Manual control is very inconvenient and it is labor-consuming, it one should avoid.

The consumption of the water, passing through the oil-cooling radiator, for one testing unit is determined from the relationship/ratio

$$G_{в} = \frac{Q_{м}}{t_2 - t_1} \ l/h \qquad (11)$$

where $G_{в}$ is consumption of the water through the radiator in l/h;

$Q_{м}$ - heat emission from oil into water in kcal/h;

t_2-t_1 - a difference in the temperatures between coming out and entering water, which takes place through the radiator, in °C.

For an entire experimental station the consumption of the water, bolt oil will compose

$$G_{в\cdot cy.м} = G_{в} n K_{одн} \ l/h \qquad (12)$$

where $G_{в\cdot cy.м}$ is total consumption of water for an entire experimental station in l/h;

G_e - the consumption of water for one testing unit in l/h;

tab $K_{одн}$ - the diversity factor of work of installations, determined on formula (8);

n - a quantity of testing units.

With the large consumption of water for oil cooling, liquid cooling of engines and cooling braking devices, it is expedient these cooling systems to switch on in the single closed loop-type system of water supply. The latter can be also used also for other needs of enterprise.

If necessary of determining the heat balance from heat emission from oil into water at entrance and exit of water from radiator, one should establish/install the sensors of telethermometers and water-gauge nozzles or washers for measurement on the differential manometer of the consumption of the entering the radiator water.

The unit of throttle water-gauge washers or it puffed it must correspond to technical requirements for their operation. Materials for tubes and the connection of oil lines are used per the GOSTs and

standards, recommended for fuel pipes.

Hydraulic design of oil system is reduced to the determination of the diameter of the suction line on the basis of the conditions of the permissible losses, the determination of losses to suction in the scavenge pipe and the determination of the position of the level in expenditure oil tank.

For calculation must be comprised the assembly diagram of oil system with the indication of entire reinforcement and connections, conduit/manifolds, rotations and linear dimensions of horizontal and vertical sections. The viscosity of oil during calculation one should accept in accordance with the temperature conditions of the normal operation of engine. The determination of hydraulic resistance is produced according to the method, presented below.

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§3 Cooling systems.

Under conditions of bench tests for piston engines in their majority, as a rule, are applied the systems of the liquid cooling which can be common/general/total for the group of testing units or individual for each stand.

Depending on the construction of engine and its temperature conditions for cooling, are applied the common open systems, working under atmospheric pressure, or the closed systems, working with overpressure.

The majority of propulsion test facilities has the open cooling systems with the application/use as the cooling fluid of water. As the target/purposes of the provision for the required thermal engine operating mode and maintenance of the necessary temperature differential of the entering and coming out water, and also for

decrease in fouling, bench cooling systems are applied mainly circulation, in which the water, which cools engine, accomplishes circular motion according to the closed diagram. Cooling the water, which circulates in this system, is produced in special heat exchangers or water-to-water radiators by the flowing cooling water, which circulates on the second heat-exchanger circuit.

The maximum permissible water hardness, which cools experimental engine in bench system, is determined by the technical specifications of its operation. The practice of the heat engineering tests of engines indicates the need of applying cooling water lower than average hardness, less than 8-10° H.

For decrease in the scale formation and corrosion, it is useful to cooling water was added bichromate - potassium bichromate. The addition of bichromate to water contributes to appearance on the surface of the metal of anticorrosive film and to the formation of the soluble salts of chromic acid, which decreases the scale deposit. A quantity of additive of bichromate depends on water hardness. Thus, for instance, with common/general/total water hardness not higher than the average of the addition of bichromate it must be 0.3o/o by weight.

The selection of individual bench or common/general/total group

cooling system is determined by technical test conditions of engine and by requirements for the production of any experimental work which can be carried out at this installation. Thus, for instance, need of determining the heat balance at installation requires the individual bench cooling system, equipped with equipment for the production of such tests. Fig. 23, depicts the schematic diagram of the bench system of water cooling in connection with production type tests of diesel 21D100. The temperature constancy of the water, entering the engine, is reached by the quantitative control of the duct of the industrial cooling water of the secondary circuit or by the bypass of the part of the primary water besides radiator.

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It is more is more conveniently this control produced automatically with the aid of temperature controller. For example, for this purpose can be used the temperature controllers of the type RTPD-80 and others.

The inconvenience of manual control is aggravated even by the facts that with the arrangement of the test benches in the isolated/insulated boxes cooling must be produced remotely from the cabin/compartment of control with the aid of handwheels and the stock/rods, connected with adjustable values.

The diameter of the conduit/manifolds of cooling system is determined by a quantity of pumped through water and by its speed.

A quantity of pumped through water is determined from the formula (9), which for cooling water assumes the form

$$G_{в} = \frac{Q_{м}}{\Delta t \cdot 60} \text{ l/min}, \qquad (13)$$

where $G_{в}$ is a quantity of pumped through water in the cooling system of engine in l/min; $Q_{м}$ is a heat emission of engine into water in kcal/h; Δt - a difference in the temperatures of water at output/yield and the engine inlet in °C.

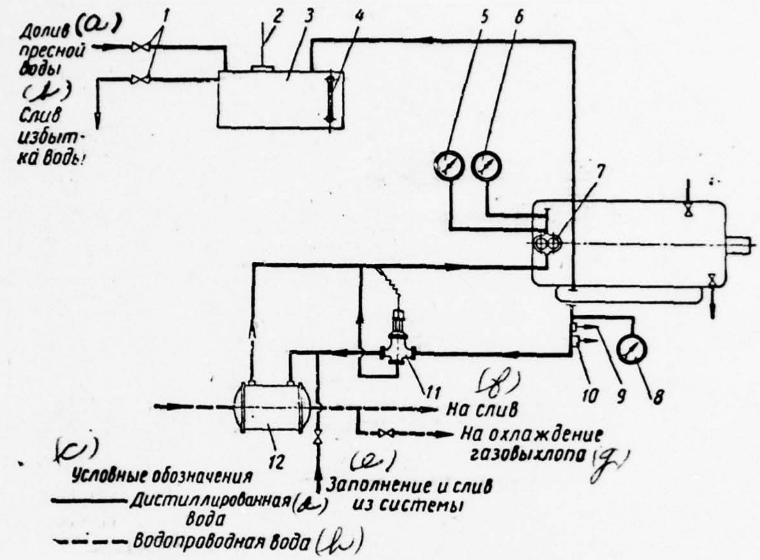

Fig. 23. The schematic diagram of the bench system of the water cooling of diesel 21D100: 1 - shutoff valve; 2 - tube for the drainage of vapors; 3 - expansion tank; 4 - gauge glass; 5 - manometer; 6 - telethermometer of the water, which enters the engine; 7 - pump; 8 - telethermometer of the water, coming out from engine; 9 - sensor of electrothermometer; 10 - sensor of the signaling of the temperature of water; 11 - temperature controller of the type RTPD-80; 12 - radiator.

Key: (a). After adding fresh water. (b). Drain of the excess of water. (c). The conventional designations. (d). Distilled water. (e). Filling and drain from system. (f). To drain. (g). For cooling of gas exhaust. (h). Tap water.

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Heat emission into water $Q_{в}$ one should accept according to the technical specifications of engine. In the absence of these data, it can be approximately accepted in size/dimension of 15-18o/o of entire heat of combustion of the introduced into engine fuel/propellant and it is determined by the formula (10), in which one should accept k = 0.15-0.18. A difference in the temperatures of water at output/yield and entry Δt of the majority of engines is 10-12°C.

The speed of water in the system of liquid cooling one ought not to accept above 2-3 m/s. The cooling water pipe must be fulfilled without abrupt changes in the flow areas and with the smallest number of bends. An inside radius of the roundings of tubes with bends must be not less than 2.5 diemeters of through section/cuts of tube.

The arrangement of conduit/manifolds must provide the possibility of deaeration from the peaks of system with its filling with water and complete drain (desiccation) from the lower points of all communications. The consumption of the water, passing through the heat exchanger of one installation and an entire experimental station, one should determine from formulas (11) and (12). During

these calculations of the value of the corresponding quantities, it is necessary to accept conformably for the system in question.

The centralized separation of water pipe for cooling of the heat exchangers of testing units must be produced by the branches, not dependent from main conduit. The water pipe of cooling water on output/yield from heat exchangers is fulfilled in the form of self-flowing, nonramming line.

All the feeding and drainage water pipes are furnished in special channels along sex/floor. The water pipes of the cold and finishing or heated water must be packed with the gradient/draft: cold water to the side of the source of supply, and heatel - to the side of its return. The gradient/drafts of water pipes are determined by the possibilities of their arrangement/permutation and are accepted by analogy with fuel pipes.

The determination of hydraulic resistance is produced according to the method, carried out into §7 of Chapter V.

The supply of cold water to heat exchangers or radiators should produce from below, and the branch/removal of the cooled heated water from above these apparatuses.

Sometimes can prove to be necessary the introduction of the preheating of the engine before starting/launching and when conducting of bench tests. This preheating can be achieve/reached by circulation by the special heated water, which is located in cooling system.

The preheating of water in cooling system can be realize/accomplished in service tank with the aid of tubular electric heaters, by hot water or vapor through the coil, and also with the aid of pair or by hot water by means of their connection to the basic outline/contour of heat exchangers. In all cases of preheating for providing the circulation of the hot water through the engine in system, must be provided for the pump with its parallel connection to the basic outline/contour of system.

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The warming heating mains and auxiliary pump are equipped by the valve/gates with the aid of which they can be disconnected from system after the heating of engine. Pairs or hot water they are connected to the intertube space of heat exchanger or radiator. Steam line is connected to water radiators on top with the branch/removal of condensate from below. For an improvement in the circulation, the heating main of the entering hot water is connected from below

radiator, and outlet water - on top.

As needed for measurement the circulation of cooling water can be produced with the aid of it metering nozzle or disk washers. Metering nozzles or washers are establish/installed on the direct/straight sections of the outline/contour of cooling system in accordance with technical specifications for their installation and operation. The more precise method of the measurement of a quantity of pumped through water, and also the determination of the heat balance of engine is produced by weight method with margin of error of approximately 0.5o/o.

In certain cases for provision, that the reliability of the operation of tested engine on the maximum permissible mode/conditions is expedient the signaling system of thermal loads and pressures to block with the cooling systems and fuel feeds, while in engines, working with electric ignition, and with ignition system.

Control of the system of water cooling must be produced from control panel of engine.

Thermometers and the manometers, which show temperature and the pressure of cooling water at entry and at output/yield e from engine, it is expedient to furnish on the central flaps of control panel.

Depending on technical requirements and the assignment of installation, the thermometers and manometers can be duplicate/backd up/reinforce by recording instruments.

Auxiliary monitoring-measuring equipment and those instruments, which do not require constant observation, can be placed on the auxiliary panels of control panel.

§4. Air-inlet systems.

These systems include the systems and the devices of the inflow of pure air into the location of experimental station for providing the complete combustion of fuel/propellant in tested engines, the ejection of waste gases for a reduction/descent in their outlet temperature, and also a device for the measurement of its consumption in all operating modes. For powerful piston engines and especially gas turbines, working with the large excess air ratio, the air flow rate for the feeding of engine and the ejection of waste gases reaches large quantities.

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If we during testing of such engines do not ensure the necessary inflow and sufficient addition/completion of air, then it can occur:

1) a reduction/descent in the power of engine as a result of considerable evacuation/rarefaction indoor of experimental station;

2) the decomposition of the separate structures of location (extrusion of windows, doors, etc.) as a result of evacuation/rarefaction because of the pressure differential between external atmospheric pressure and reduced pressure indoor of testing unit.

The air flow rate by engine is determined from the condition of the complete combustion of the fuel/propellant

$$G_{возд.дв} = \frac{G_{топ} L_0 \alpha}{3600} \text{ kg/s.} \quad (14)$$

where $G_{возд.дв}$ is air flow rate by engine in kg/s; $G_{топ}$ - the hourly consumption of fuel/propellant by engine in kg/h; L_0 is the quantity of air, theoretically necessary for complete combustion 1 kg of fuel/propellant. For gasoline, kerosene and diesel of fuel/propellant L_0 ~~ 14.7 kg of air on 1 kg of fuel/propellant; α - the excess air ratio is determined from the engine characteristic. In the absence of these data for calculations with sufficient

accuracy/precision, it is possible to accept: for piston engines α = 0.95, for gas turbines α = 4.0.

If necessary for cooling waste gases by mixing length of their with the ejected air its flow rate will be determined by a quantity of gases, by their initial temperature and the final temperature of mixture. The ratio of a quantity of air, necessary for cooling, to a quantity of waste gases, coming out from engine, taking into account their temperature state will be determined by the coefficient of ejection, which can be obtained from the relationship/ratio

$$K_n = \frac{t_{\partial в} - t_{кон}}{t_{кон} - t_{атм}}, \qquad (15)$$

where K^u is a coefficient of ejection; $t_{\partial в}$ is temperature of exhaust gases on leaving from engine in °C; $t_{кон}$ is the final temperature of mixture in °C; $t_{атм}$ - the temperature of the ejected air in °C.

The temperature of waste gases on leaving from engine one should accept according to the technical specifications of engine. For diesels this temperature comprises $t_{\partial в}$ = 700-800°C, also, for remaining piston internal combustion engines $t_{\partial в}$ = 800-900°C.

For gas turbines $t_{\partial в}$ = 400-600°C.

The final temperature of the outgoing mixture of waste gases

with air must be determined by that maximum permissible temperature which can long and reliably maintain the constructions of the gas-discharge and soundproofing devices. Data on these temperatures are given in Chapter VIII.

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The temperature of the ejected air one should accept according to the temperature of surrounding air of relatively prolonged period in summer as more adverse conditions for cooling of the mastered gases. For areas of moderate room this temperature it will comprise $t_{am.н} =$ $= 25°C$.

Thus, the complete air flow rate for providing the complete combustion of fuel/propellant in tested engines taking into account the air flow rate for the ejection of waste gases for one testing unit will comprise

$$G_{пол\cdot возд} = G_{возд.дв}(1 + K_n) \text{ kg/s}, \qquad (16)$$

where $G_{пол\cdot возд}$ is complete air flow rate for one testing unit in kg/s; $G_{возд\cdot дв}$ - the expenditure/consumption of air of engine in kg/s; K_n is a coefficient of ejection.

With the arrangement of several testing units in one location, the complete air flow rate, determined by formula (14), must be increased by the number simultaneously of working installations. For the purpose of the compensation for the inflow of the expendable air it is necessary indoor testing units to provide for supply or as them are frequently called, the air-suction shaft/mines and channels. If necessary they are equipped by the sound-deadening devices, since on high noise level indoors of the experimental station through these shaft/mines noise it will penetrate outside.

Air-intake shaft/mines can be both individual for each testing unit and common/general/total for several installations, if in this case noise propagation on them will not be interference/jamming for adjacent installations.

The hydraulic resistance of intakes must be minimum. For this reason, and also to avoid the blowing of sound-absorbings material the air speed in the zone of soundproofing must not exceed 15-20 m/s. The total resistance of air-inlet system must not exceed 60-80 mm H_2O. When, in the experimental location, evacuation/rarefaction is present, more indicated tested engine not in state will develop total power, as they speak, will occur the deficit of the power of engine, which disturbs the limit of the required accuracy of measurements.

For a reduction/descent in the hydraulic resistance, one should to gear down air flow, to improve the conditions of entry and output/yield of this, to apply special fairings in soundproofings during a change in the flow direction provide for cascades and other measures, directed for improving the outline/contour of input device.

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It is necessary to also focus special attention on the provision for purity/finish of the air, which goes to the feeding of engines. Especially this concerns the gas turbines which are extremely demanding to purity/finish. The presence in suction air of dust, small construction particles, grains of slag, carbon and solid particles, which are located in suspension, causes nicks on compressor rotor blades and turbines, distorts their airfoil/profile, in consequence of which is decreased by their efficiency, the service life of work and strength. To the same degree the obstructibility of air detrimentally affects the work also of piston internal combustion engines. Therefore the regular arrangement of experimental station and air-intake shaft/mines gains importance. As far as possible them it is necessary to remove from shops and the productions, which contaminate the air, such as foundry shops, boiler, the storages of carbon and other similar materials, the production of friable building materials. In the presence of the strong dust content of

surrounding air in area of experimental station and in the absence of air filter of engine during its testing the bench system of air supplu must have filtration of air. It can be realized by the following methods: a dry method - with the aid of surface or porous filters; by wet process - the means of oil filters; in an inertia manner - with the aid of inertia dust arresters; electrically - by the electrification of dust. The method of filtration one should select depending on the degree of obstruction, composition of particles and air flow rate. As One Of the simplest constructions of dry filter can serve the vertically arranged/located in two series zinc-coated grid with cells 1.4 x 1.4 mm and 0.65 mm in gauge. The distance between grids must be 250-300 mm and furnish them should the air-intake silencers. With the air flow rate, it is more than 20-30 kg/s to more expedient apply inertia dust arresters and electric filters. With smaller expenditure/consumptions simpler will be the oil, so-called viscin filters. The latter consist of standard cells 500 x 50 mm in size/dimension of, filled by bushings from ceramics. The thickness of filling is 75-100 mm. For the wetting of bushings, is applied slowly drying viscin or motor oil. The periodic purification/cleaning of contaminated filter sections is produced by their dipping into bath with hot soda solution. Design load on one cell is accepted within limits 0.25-0.30 kg/s, in this case the resistance of this filter is 7-8 mm H_2O.

To avoid the suction of waste gases into receiving air duct, the partition branch connection of the latter must be removed from the end of the gas-bleeding tube or arrange/located its below outlet. Since coming out waste gases have velocity head and temperature, which considerably exceeds the surrounding atmospheric air, their flow will be directed upward along vertical line. Therefore it is expedient the gas-bleeding tube to furnish higher than air-inlet branch connection. In this case, the difference in height/altitude must be not less than 3-5 m. In the case of the impossibility of their this arrangement one should remove from each other.

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As far as possible it is necessary to approach that so that the air-inlet branch connection would be arrange/located from windward, and gas escaping from the lee side relative to the direction prevailing winds. Especially this is related to the powerful testing units which have air flow rate several kilograms per second and it is above.

Air-inlet branch connection is furnished horizontally or is vertical. In the latter case it must be equipped by the canopy, which shields air duct and silencers from precipitation of atmospheric residue/settlings. To avoid the incidence/impingement into the system

of dust from the roof of building, the branch connection must be removed from roofing up to distance not less than 1 m. On the end of the air duct, is establish/installed also the rare wire gauze, which prevents from the incidence/impingement in it of foreign objects. All the connections of air ducts and coming out gas pipes must be hermetically sealed, but their sections, that pass within building, are heat-insulated. Besides the filtration of air, the structure of the working surface of air-intake channel must be stable to efflorescence and not allow/assume the isolation/liberation of construction particles and dust. For strengthening and surface protection of the structure of this channel, it is expedient to produce the pasting of its gauze on bakelite varnish with the subsequent coating with nitrocellulose enamels.

§5. Gas-bleeding systems.

The systems of gas bleeder serve for the removal of waste gases, they can be accepted along the system of the open or closed gassing. The system of open gas outlet consists in the fact that the gas-bleeding collector/receptacle of engine or its nozzle does not have direct connection to gas exhaust channel or conduit/manifold. In this case waste gases on certain small section occur/flow/last over

air without conduit/manifold. In this case, the air, which surrounds the coming out gas jet in this area, is carried along by it and together with jet it heads for the receiving branch connection of the gas-bleeding system.

The system of closed gas bleeder does not have the indicated breakage of conduit/manifolds, but therefore in it there is no ejection of surrounding air.

The selection of one or the other system of the distance/removal of waste gases depends on requirements and conditions of the work of installations.

Closed gas bleeder is applied:

1) with the arrangement of bench installations in common/general/total hall, since the closed gas bleeder considerably decreases noise level indoors of experimental stations;

2) if noise level during engine testing is relatively small and in the gas-bleeding system are not required to establish/install the sound-deadening devices with temperature limitations;

3) when according to test conditions it is not required to

observe of the yield of waste gases for determining their smokiness, color of flame, uniformity and combustion stability.

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The open gas bleeder makes it possible:

a) induced air for its mixing with waste gases for the purpose their temperature decrease. This is necessary during the equipment of the gas-bleeding system by the sound-deadening devices;

b) to observe of the coming out jet of waste gases.

The common/general/total gas-bleeding systems, which operate several testing units both of closed and open gas bleeder, must be equipped with the special smoke sucking or suction ejector devices. To avoid the overflowing of waste gases through air-intakes opening of adjacent installations in the gas-bleeding system, it is necessary to create evacuation/rarefaction.

If the hydraulic resistance of the individual systems of the open or closed gas bleeder does not exceed the permissible value, they can not have forced drawing.

For piston engines without the perceptible error, within the limits of the required accuracy of the measurement of power, the common/general/total hydraulic resistance is admissible to 300-400 mm H_2O. For gas turbines this resistance depending on the value of the total pressure in the section/shear of the gas-bleeding nozzle can be the more than indicated value. In this case, one should have form that for both types of engines in all cases the total pressure of waste gases in the section/shear of outlet must exceed the hydraulic resistance of entire channel of the gas-bleeding system. Section/cuts, dimensions and the hydraulic resistance of these channels are designed from the flow rate of waste gases or their mixture with inducing air or with the pairs of cooling water.

The weight flow rate of waste gases will correspond to the flow rate of the air, necessary for the complete combustion of fuel/propellant, determined from formulae (14) or (16) with the addition to it of weight of flow of the combustible in engine fuel/propellant. For the installations, working with closed gas line, this flow rate will compose

$$G_{omp.zaз} = G_{возд.дв} + G_{топ} \text{ kg/s} \qquad (17)$$

where $G_{omp.zaз}$ is a flow rate of waste gases one by unit in kg/s;

$G_{возд.дв}$ - the air flow rate for the feeding of engine in kg/s;

$G_{топ}$ - a fuel consumption by engine in kg/s.

The flow rate of waste gases at the units, working with the addition of the ejected air, will be determined:

$$G'_{отр.газ} = G_{возд.пол} + G_{топ} \text{ the kg/s} \quad (18)$$

where $G_{отр.газ}$ is a flow rate of waste gases one by unit with the ejection of air in kg/s;

$G_{возд.пол}$ - complete air flow rate for the feeding of engine and for ejection for one unit in kg/s;

$G_{топл}$ - a fuel consumption by engine in kg/s.

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A gain in weight of waste gases because of the products of fuel combustion against the weight flow rate of air, consumed by engine, in formula (17) is virtually 6-6.5o/o for piston and 1.7-2.0o/o for gas turbines. For determining the section/cuts of the air-inlet and gas-bleeding channel, it is necessary tc know the volumetric flow

rate of air and of waste gases or their mixture with air which is determined from the formula

$$Q = G/\gamma \ m^3/s. \qquad (19)$$

where Q is a volumetric flow rate of air, of waste gases or their mixture in m^3/s; G is the weight flow rate of the same gas in kg/s; γ is the specific weight of gas in kg/m^3.

The specific weight of gas is determined from the relationship/ratio

$$\gamma = P/RT \ kg/s, \qquad (20)$$

where P is pressure in kg/m^2; R is a gas constant in kgm/kg°C; T is absolute temperature in °K.

For the calculation of air-inlet and the gas-bleeding systems with sufficient accuracy/precision for air, waste gases or their mixture with air it is possible to accept: P = 10 330 kg/m^2, R = of 29.3 kgm/kg °C. So, the specific weight of standard air (at temperature of 15°C) will comprise

$$\gamma = \frac{10330}{29,3\,(273+15)} = 1.226 \ kg/m^3.$$

The necessary section/cut of channel will be determined from the expression

$$F = \frac{Q}{w} \text{ м}^2, \quad (21)$$

where F is effective area of channel in m^2; Q is a volumetric flow rate of gas in m^3/s; w is the average speed of the flow of gas in m/s.

For providing the reliable and continuous operation of the constructions of the gas-bleeding system and sound-deadening devices, waste gases are subject to cooling.

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In practice widest use received the following methods of cooling;

1) by air, by means of ejection by its coming out jet of waste gases or during the supplying its into the gas-bleeding system from the air injector, pneumatic from compressor or from air extractor;

2) by means of water injection into the gas-bleeding channel;

3) with the aid of the unit of heat exchanger;

4) by the combined method, by means of the coincidence of the preceding/previous methods.

The simplest and widespread method of cooling outgoing waste gases is the first and partially second methods. For the individual gas-bleeding systems most frequently, especially for gas turbines, is sued the ejection of air because of the use of kinetic energy of the most coming out gas jet. For the testing units, which have the common/general/total gas-bleeding systems, this method cannot be recommended as a result of the possibility of the overflowing of the mixture of waste gases through the gas-collecting branch connections of adjacent installations. In this case are necessary to additionally establish/install special exhaust fans or the auxiliary ejectors, the pneumatic for maintaining certain evacuation/rarefaction in the system of gas bleeder and overcomings of its hydraulic resistance. The procedure of calculation of ejectors is given in [9]. Using the given below approximate data, sometimes the ejector is selected and manufacture experimentally. Fig. 24, gives the diagram of the ejector of the gas-bleeding system of testing unit with the ejection of air by the outgoing jet of waste gases. Behind nozzle 1 waste gases head for ejection pipe 2, which has diffuser 4, and further for the gas-bleeding tube or muffler 5. A quantity of air, ejectel by the jet

of waste gases, will depend on the relationship/ratio of diameters d_2/d_1 and of distance l_1 between the nozzle and ejection pipe. The greater this relationship/ratio and the distance, the greater the flow rate of ejected air.

For providing the distance/removal of waste gases and correct work of ejector, must be observed following conditions: the diameter of ejector $d_2 \approx 1.05\ d_1 + 0{,}4 l_1$; the length of ejector $l_3 \geqslant 4-5\ d_2$; the length of diffuser $l_4 \geqslant 2.5-3\ d_2$; the length of receiving socket $l_2 \approx$ $\approx 0.05\ d_2$; the convergence angle of receiving socket 30°; the divergence angle of diffuser 4-5° (for each side from the axle/axis of diffuser).

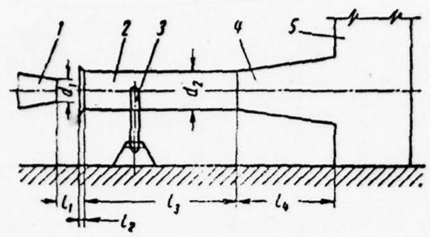

Fig. 24. Diagram of ejector for exhaust gases: 1 - exhaust nozzle; 2 - ejection pipe; 3 - tip bearing; 4 - diffuser; 5 - vertical muffler.

Page 79. The gas-bleeding conduit/manifolds, in which can occur the accumulation of unburned fuel/propellant or its vapors (for example, during the cancelled starting/launching), must be equipped with drainage and blowoff devices for the prevention/warning in them of possible explosion. Air gas pipes must have minimum hydraulic resistance, and therefore in them are not allow/assumed sharp rotations and transfer/transitions. The bent or welded elbows as far as possible must approach a circumference with a radius to the axle/axis of tube $r \geqslant 3D$, where D, the diameter of pipeline. The design of the sound-deadening devices of systems and, gas bleeders are given in chapter VIII.

§6. Cooling waste gases by water injection.

A reduction/descent in the temperature of waste gases in the gas-bleeding system by means of water injection is the most effective method. It gives noticeable noise reduction at the yield of gases because of a considerable decrease in their volume during cooling and a corresponding decrease in the velocity.

A reduction/descent in the temperature of waste gases by means of water injection can be reached with the observance of following conditions. It is first of all necessary to ensure the fine/thin atomization of water, for which it one should supply to injectors under pressure not less than 6-8 kg/cm². For the best heat transfer from the coming out gases to water, its heating and evaporation, is necessary the determined contact between them. This contact is determined by the necessary time of the interaction of the speed of its flow and by the length of the section of the gas-bleeding channel. The overall length of channel will depend on the initial and final temperature of gases.

In connection with waste gases of the engines in question temperature balance along the flow of bulk of gases begins not earlier than the passageway from 8 to 12 m of the length of the section of gas line of the site of installation of the injectors,

which inject cooling water.

The consumption of water under the condition of its complete evaporation and superheating pair will be determined from the equation of the balance of the heat

$$G_г c_г (t_н - t_к) = G_в c\,[(t'_к - t'_н) + 539 + c_п (t_к - t'_к)],$$

whence

$$G_в = \frac{G_г c_г (t_н - t_к)}{c\,[(t'_к - t'_н) + 539 + c_п (t_к - t'_к)]} \text{ kg/s.} \quad (22)$$

where $G_в$ is expenditure/consumption of water in kg/s; $G_г$ is a gas flow in kg/s; $c_г$ is heat capacity of gas 0.24 kcal/kg•deg; $t_н$ is initial temperature of gas in °C; $t_к$ is the final temperature of gas and the steam in °C; c ~~ 1 - the heat capacity of water in kcal/kg• °C; $t'_н$ - the initial temperature of water, is equal to 15°C; $t'_к$-the final temperature of water, is equal to 100°C; 539 - latent heat of vaporization in kcal/kg; $c_п$ - heat capacity is the pair, equal to 0.5 kcal/kg•deg.

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The water, which goes flash for cooling of waste gases, changes their weight and volumetric composition.

Furthermore, with the combustion of fuel/propellant they are formed the steam which also affects the volumetric composition of the mixture of waste gases and the steam. All these changes one should consider during the determination of required dimensions and section/cuts of the gas-bleeding channel.

For determining the specific weight of mixture γ from formula (20) and the volumetric flow rate of mixture from formula (19) we find common/general/total gas constant $R_{общ}$.

A quantity of the steam, obtained with the combustion of fuel/propellant, taking into account an average quantity of vapors, which are found in air, will comprise

$$G_n = 1{,}6\,\frac{G_т}{3600}\ \text{kg/s.} \qquad (23)$$

where G_n is a quantity of the steam in kg/s; 1.6 coefficient, which considers a quantity of forming steam with combustion 1 kg of fuel/propellant, on the basis of the weight content of hydrogen, which is located into the fuel/propellants also of the connected to it atmospheric oxygen, and also taking into account an average quantity of water vapors, which are found in standard air; $G_т$ is a fuel consumption in kg/h.

The total weight of the steam will comprise

$$G'_{в} = G_{в} + G_{п} \text{ kg/s,} \quad (24)$$

where $G'_{в}$ is the total weight of the steam in kg/s; $G_{в}$ is expenditure/consumption of water for injection in kg/s; $G_{п}$ is a quantity of the steam, obtained with the combustion of fuel/propellant, taking into account the steam, which are found in air, in kg/s.

The weight of dry gas we will obtain by the subtraction of the weight of the steam from common/general/total weight of gas:

$$G'_{г} = G_{отр.газ} - G_{п} \text{ kg/s,} \quad (25)$$

where $G'_{г}$ is weight of dry gas in kg/s; $G_{вых\cdot газ}$ - the expenditure/consumption of waste gases, determined by formula (17) or by formula (18), in kg/s; $G'_{в}$ is the total weight of the steam, determined by formula (24), in kg/s.

The total weight of mixture $G_{см}$ we will obtain by the summation of the weight of dry gas $G'_{г}$ and of the weight of the steam $G'_{в}$, those who were determined from formulas (25) and (24),

$$G_{см} = G'_г + G'_в \text{ kg/s.} \qquad (26)$$

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The gas constant of mixture $R_{общ}$ will be determined from the expression

$$R_{общ} = 47{,}1 \frac{G'_в}{G_{см}} + 29{,}3 \frac{G'_г}{G_{см}} \text{ kgm/kgfm,} \qquad (27)$$

where 47.1 and 29.3 are gas constants respectively for the steam and exhaust gases.

The obtained value gas constant mixture $R_{общ}$ one should substitute into formula (20) for determining the specific weight of mixture and subsequent volumetric flow rate of mixture.

For water injection, are applied angular or tangential injectors, arrange/located on water-conducting collector/receptacle in the initial section of ejection pipe or gas pipe.

With the diameter of injector 6 mm, the consumption of water is 0.3 kg/s. To avoid falling of water into box or in the location of the testing units of injector one should establish/install at certain angle to the flow of gases, which coincides with the direction of

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EXPERIMENTAL STATIONS OF PISTON AND GAS TURBINE ENGINES,(U)

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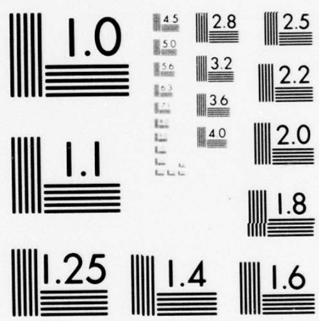
1.0
4.5
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5.6
6.3
2.8
3.2
3.6
4.0
2.5
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1.8
1.25
1.4
1.6

water injection from engine. For providing continuous operation of the system of injection, it is expedient to provide for basin with pump in order to ensure pressures indicated above of the water before injectors.

§7. Determination of the flow rate of air and hydraulic resistance.

1. Air flow rate.

During experimental studies and taking of standard characteristics, sometimes it is required to determine the expenditure/consumption of the air, which enters the engine. This need appears also during testing of superchargers and compressors both piston engines and the gas turbines.

In these cases the testing units are equipped with the device, which makes it possible to produce the measurement of the air flow rate.

From the most widely used methods such measurements can be produced with the aid of throttle instruments or the pneumatic tubes,

adjustable in intake air ducts. Sometimes the measurement of the air flow rate can be produced after waste gases with the aid of the special rack, adjustable in the section/shear of gas exhaust nozzle or branch connection.

The measurement of the air flow rate is produced on the speed which is determined by pressure difference before and after throttle instrument. This pressure difference is measured by differential manometer, and further analytically is calculated expenditure/consumption according to the procedure, given in [10].

With all methods of measurements for determining air density simultaneously with pressure is produced the measurement of its temperature.

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Temperature of air at the inlet into engine it should be measured with low-inertia resistance thermometers in assembly with multiposition measuring bridge and galvanometer.

The temperature of air and gas through the channel of engine and in section/shear is measured by chromel-drop and chromel-alumel thermocouples with readings according to galvanometer.

2. Determination of hydraulic resistance.

The feed systems of air and gas bleeder, and also the power-supply system of testing units by fuel/propellant, oil and water frequently require the determination of hydraulic resistance for testing of their throughput capacity, selection of pumps, pumps and another equipment with the necessary pressure for providing the duct of liquids and gases.

Especially this is important for the air-inlet and gas-bleeding systems, since in them in the majority of cases are determined limitations on the permissible evacuation/rarefaction and the available pressure.

The common/general/total hydraulic resistance of these systems during the flow on them of gases and liquids is composed of two parts

$$\Delta p = \Delta p_{\tau p} + \Delta p_{м} \text{ kg/m}^2, \quad (28)$$

where Δp is the common/general/total hydraulic resistance of the

outline/contour of system (channel or conduit/manifold) in kg/m²; $\Delta p_{\tau p}$ - frictional resistance over entire length of outline/contour depending on flow conditions (Reynolds number Re) and of surface condition of friction or degree of roughness in kg/m²; $\Delta p_{м}$ - the local resistance, caused by local vortex formations and the redistribution of the speeds in the shaped pieces of the conduit/manifold, fittings and other barrier/obstacles, depends on their geometric forms and size/dimensions in kg/m².

Frictional resistance is determined from the formula

$$\Delta p_{\tau p}=\lambda \cdot \frac{l}{d} \cdot \frac{w^2}{2g} \cdot \gamma \qquad (29)$$

where λ is a coefficient of friction drag of the unit of the length of conduit/manifold (channel); l - the overall length of conduit/manifold, including the length of its shaped pieces, in m; d - the diameters of conduit/manifold in m; w - average rate of flow (gas or liquids) in m/s; g = 9.81 m/s² - the acceleration of gravity λ is the specific gravity/weight of gas or liquid in kg/m³.

The coefficient of friction λ - depends on flow conditions (Reynolds number Re), and it one should determine according to handbooks, see [5].

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Loss of pressure in local resistance is determined from the formula

$$\Delta p_м = \zeta_1 \frac{w^2}{2g}\gamma + \zeta_2 \frac{w^2}{2g}\gamma + \ldots + \zeta_n \frac{w^2}{2g}\gamma \text{ kg}/м^2, \qquad (30)$$

where ζ_1, ζ_2, ..., ζ_n - coefficients of local resistance in the separate shaped pieces of the conduit/manifold, fittings and other barrier/obstacles and devices, arrange/located over entire length of system.

During the determination of common/general/total hydraulic resistance from the outline/contours of the systems of fuel, oil, that cools one should consider losses or pressure excess from liquid column in conduit/manifolds and the capacitance/capacities, which form part of system, but arrange/located below or higher than testing unit.

In the indicated calculations for all systems, one should disregard the elasticity of vapors of liquids, since their content is virtually insignificant.

[Page 84] Chapter VI

SAFETY CONTROL AND INDUSTRIAL SANITATION AT EXPERIMENTAL STATIONS.

§1. Safety engineering and industrial sanitation.

1. General considerations.

The questions safety and industrial of sanitation technique include entire complex of the equipment of devices and organizational and technical measures, which eliminate traumatism and occupational diseases and which ensure the normally permissible sanitary working conditions, harmless for the health of workers in this production.

General considerations with respect to the provision safety and industrial of sanitation technique are establish/installed and are regulated by the union inspections of Gosgortekhnadzor and by state sanitary inspection. For each production taking into account its specific special feature/peculiarities, these organizations can

establish/install in places additional requirements and conditions in the form of orders, resolutions, commands and instructions, directed toward survival and health of workers and employed. Control of the execution of these solutions is laid on the representatives of the indicated organizations, and also on the technical inspector of the council of trade unions and on inspector on the industrial safety measures of plant trade union committee. The administrative-technical personnel of enterprises is due daily to keep track of the state safety and industrial of sanitation technique on its sections and to take all measures to a further improvement in the working conditions.

Persons, guilty of nonobservance and disturbance/breakdown of the established/installed positions and instructions, by inspections indicated above are drawn on responsibility according to the effective legislation.

For experimental stations and laboratories, general considerations on safety and industrial sanitation technique are reduced to following basic requirements.

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2. Requirements with respect to device and equipment of experimental

stations.

For the purpose of the safety control of the service personnel on tests and the safety of engines, it is necessary in testing units to provide the blocking of starting/launching system with the propellant feed systems and air and the coverage of gates and doors of bench cabin/compartments.

Device, ventilation and the illumination of production locations, composition and the size/dimensions of everyday and office locations are regulated by norms N 101-54.

A quantity of harmful isolation/liberations, which are contained in air of working locations, is limited to their maximum permissible concentrations, given in appendix 1.

The maximum permissible noise level in production locations and outside them is establish/installed according to time/temporary sanitary norms (see appendix 2).

In the case of possible at testing units fires, explosions, breakaway of the rotating parts and other emergencies, which threaten safety the service personnel, bench units must be arrange/located in

the isolated/insulated boxes. In this case, the personnel, which generates testing, must be located in the isolated/insulated from box location (cabin/compartment of control), of wall, observation window and door of which with emergencies must ensure fullest safety.

At the test benches and the laboratory units where the safety the service personnel can threaten the breaks of rotating parts either the tightening of their clothing in the rotating parts of mechanisms, or into the jet of stack gases or into the air-inlet branch connections of engines, compulsorily must be establish/installed shielding enclosure/protections in the form of grids, handles, etc.

Bench staircases with walking on them more than one times into replacement must have slope angle not more than 45°. The working surface of area/sites, ladders, bridges and step/stages of staircases for the purpose of the exception/elimination of the slip of struts, especially with spilled oil, they must be covered with corrugated iron or to be manufactured in the form of grates from the steel plates, up-edge or by means of the burn-in of the welded joints.

Is not allow/assumed the device of hoisting or blinds gates for the apertures through which during tests can pass the people.

The bench etcetera equipment of the testing units in which is establish/installed the electrical equipment or are installed electric systems, they are subject to grounding. Movable illuminating tubes must work under voltage/stress not more than 36 V.

Vessels and equipment, workers under pressure are more than 0.7 atm(gage), with the value of the product of their volume in liters by pressure in atm(gage), it is more than 200 unity, must be manufactured, be installed and operate with the observance of norms and rules of Gosgortekhnadzor (see the "rules of device and safe operation of the vessels, working under pressure", affirmed by Gosgortekhnadzor of the USSR 17/XII 1956).

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Device and the operation of cargo mechanisms must be realize/accomplished in accordance with the "rules of device and safe operation of cranes", affirmed by Gosgortekhnadzor of the USSR 5/VII 1957.

3. Safety of works on testing units.

Bringing into service of the newly equipped or reconstructed production shops, compartments, laboratories or separate testing units, including of cargo mechanisms, vessels, working under pressure, and other similar to them objects must be produced only after the compilation of the acceptance event/report of board with necessary collaboration in this board of the chief of bureau of safety engineering of enterprise and technical inspector of the council of trade unions.

In the necessary cases or of the requirement for the chief of bureau of safety engineering of enterprise is compulsory also the collaboration of the representatives of Gossaninspektsiya, Gospozhnadzor and Gosgortekhnadzor.

The conduct of supervision after the safe organization of works and the safe state of the equipment of production locations and devices, the compilation of commands on safety engineering, conducting instruction with the newly taken workers, the provision for workers with special clothing, special boot and protective devices is laid on the administrative-technical personnel of enterprise. Works with leaded gasoline must be produced in accordance with "sanitary regulations on storage, transportation and the application/use of leaded gasoline in motor transport" after No 193-55, affirmed by the main Gossainspektsiya of the USSR.

One should remember that leaded gasoline possesses toxic properties and can cause heavy poisonings with its incidence/impingement for skin covering, with its ingestion or during the inhalation of its vapors. The preparation of leaded gasoline, i.e., the mixing of gasoline with ethyl fluid, must be produced only in the specially equipped gasoline mixing stations and by authorization of local Gossaninspektsiya. The experimental stations and the laboratories of engines, which apply leaded gasoline, must be equipped with sanitation points.

During the use of the mercury pressure gauges [1] of work with mercury, they must be organized and to be fulfilled in accordance with "command on the device and the sanitary content of locations in works with mercury in laboratories", affirmed by the main Gossaninspektsiya of the USSR 8/V 1941.

FOOTNOTE [1]. For the purpose of the prevention of poisonings, the application/use of the mercury pressure gauges (piezometers) follows as far as possible to avoid, completely or maximally to reduce. Piezometers it should be replaced by group pressure recording gauges GRM-2, manufactured with the plant "Tizpribor," this non-mercury

instrument can simultaneously measure and record/write pressures or the pressure differential simultaneously at 20 points. ENDFOOTNOTE.

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In the mercury pressure gauges the glass tubes must be closed by organic glass, in the lower part of it must be the collection for the catching of mercury during the possible destruction of tubes, and at upper jets, must be valves or devices for the catching of mercury with ejection. For the elimination of the possibility of the output/yield of toxic mercury vapor from measuring meter into location surface of mercury, it must fill with shielding liquid or at output/yield from instrument must be placed the recovering filters with the activated carbon and active manganese dioxide.

§2. Fire-fighting safety.

1. General considerations.

The field of fire-fighting safety includes entire complex of the equipment of devices and measures, which eliminate explosions fires

in experimental stations in the laboratories of engines or gas-dynamic during their operation. According to the character of the production of the tests of thermopower engines, the seats of fires can occur; however, they must be abbreviated/reduced to the minimum and bear local character with the provision for localization and complete liquidation in short time.

Construction and the operation of the productions, which apply the inflammable and combustible substances, are regulated by the appropriate norms and commands. Besides the union norms of state committee in the matters of building USSR. "Fire-fighting norms and the technical specifications of the design of the storages of the inflammable and combustible substances according to NiTU 108-56" and the "rules of the device of electrical equipment" of the ministries of power stations, usually are departmental rules and commands, comprised in connection with the special feature/peculiarities of each production and the supplementing indicated positions. Those guilty of nonobservance and violation of norms, rules and commands on device and operation of enterprises as a whole and of its separate shops and services are drawn on responsibility according to the existing legislation.

In connection with experimental stations and laboratories, the essence of these norms and commands is reduced to following basic

requirements.

2. Fire-fighting requirements with respect to device and equipment of experimental stations.

Buildings and the departments of experimental shops and laboratories of engines or gas-dynamic laboratories are related as a whole to category "G", i.e., to flammable constructions. Separate services and locations can be and other categories depending on their designation/purpose.

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In appendix 3, are given the categories fire- and the explosiveness of individual sections and services of these shops, and also the classes of the device of electrical equipment.

Power electric systems, illumination and electrical equipment must be installed in separate locations and services in accordance with the "rules of the device of electrical equipment" and by the classes of these locations, see appendix 3.

During the construction of buildings and the equipment of experimental stations and laboratories, must be applied flameproof materials. The sound-absorbing constructions on gas bleeders also must be made from flameproof materials. In flammable locations must be provided the possibility of the emergency evacuation of working in them personnel. In such locations, by area it is more than 200 m², must be not less than two output/yields, as far as possible arrange/located in opposite sides.

Dangerously explosive locations (category A and B) must be furnished in the single-story buildings, above them is not permitted the device of production, auxiliary and other services with remaining in them the service and other personnel. In these rooms must be knock-out surfaces in the form of windows, doors and light/lung partition/baffles, but therefore one should furnish them at external walls.

Within the buildings of experimental stations and laboratories and above these buildings is not permitted device of the fuel expenditure and other capacitance/capacities above 500 l.

The supply of testing units with fuel/propellant is recommended to realize/accomplish by the centralized way - on conduit/manifolds with pump feed or extrusion by the compressed air from the storage or

the fuel reservoir, arrange/located outside building.

The section, on which are arrange/located the ground-based cisterns of fuel reservoir, on fire-fighting requirements must have the earth embankment, which eliminates the overflow of fuel/propellant on territory. The rules of device, necessary area/site, the breakage between the storage and other its constructions from general lay-out are determined by union fire-fighting norms and the technical specifications of the design of the storages of the inflammable and combustible substances according to NiTU 108-56, by the fire-fighting norms of the construction design N 102-54 of state committee for the matters of building with the CM USSR, and also by the rules of the device of electrical equipment PUE [' - Rules for setting up electrical installations] of the Ministry of power stations.

The main conduits of the centralized fuel supply should be laid from the outer side of building. The sections of the fuel lines to units and stands within building must be laid in the separate channels in which must not be located the heating mains, electric cables and other communications. These channels after the installation of fuel lines must be filled by dry sand.

The centralized fuel lines input into building must be equipped

with shutoff valves with free access to them for their coverage.

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Bench fuel systems in the case of the possible emergence of fire must have high speed emergency cranes (of type "gate valve"), given into action from the panel for control.

Of all bench capacitance/capacities of the fuel system: expenditure small tanks, instruments, reinforcements and conduit/manifolds must be provided for the emergency self-flowing fuel dumping in fuel reservoir or the various capacitance/capacity, arrange/located outside building.

In the case of possible overflow or reverse/inverse ejection of fuel/propellant, one should provide for drainage system. It must consist of drain ladder for the collection of fuel/propellant, conduit/manifolds, packed with gradient/drafts for providing for a self-flowing drain, and the special drainage capacitance/capacity, arrange/located outside building and that which was sunk into the earth/ground. This capacitance/capacity must have a device for the periodic evacuation from it of fuel/propellant into movable tare.

Experimental stations, the laboratories of engines and

gas-dynamic laboratories are equipped by the means of fire extinguishment, a composition and quantity of which is determined in each specific case depending on the equipment of station and special feature/peculiarities of the technological process of tests. Besides conventional means of fire extinguishing in the form of the fire hydrants with hose/pipes, froth and dry fire extinguishers, boxes with dry sand, can also be applied the stationary or mobile units of the systems of gas extinguishment of fires. If necessary for the quenching of the ignited on workers clothing or engine itself, and also of the for localization local seats of fire it must be provided for are felt.

For the distance/removal of vapors of the spilled volatile fuel, one should provide the forced suction and exhaust ventilation, which eliminates the formation of the dangerously explosive concentrations of the mixtures of propellant vapors with air. To avoid extrusion additional air of inflammable propellant vapors into adjacent locations the productivity of exhaust ventilation, as a rule, must be higher than supply for providing certain evacuation/rarefaction in the ventilation location.

Since the pairs of fuel/propellant heavier than air, they are capable of flowing in and being store/accumulated in the lower arranged/located locations. Therefore one should not in experimental

stations and laboratories arrange basements, passage tunnels, the galleries etc., of construction. If necessary for the device of the same for them, also one should provide for the forced ventilation.

3. Measures of fire-fighting safety.

Depending on the type of fuel/propellant, arrangement and character of the locations of electric wire, power and lighting electrical equipment they are fulfilled through agreement with the organ/controls of Gospozhnadzor in the shielded, closed or explosion-proof performance.

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To avoid the formation of the dangerous in fire sense discharges of the static electricity, which is formed with course along pipes of bright oil-products, all fuel lines both external and internal are subject to reliable grounding.

All sections of fuel pipes must be metallically solidly connected, have a good contact, represent single electrical circuit. the metallic contact of all component/links of fuel pipes is reached

by threaded connections and joints of each pair of flanges by metallic brackets. The latter can be made of the steel strip by section/cut not less than 35 mm^2, on the ends of the bracket, they must have holes for their unit under the bolts of flange joint. For providing the reliable electrical contact, the surface of flanges, brackets and bolts in points of connection thoroughly is cleaned to metallic luster.

The electrode of grounding must be metallic with anticorrosive surface not less than 0.5 m^2. This electrode is connected with conduit/manifolds by conductor not less than 6 mm in diameter with the aid of welding or rations. The electrode of grounding will be sunk into the earth/ground to damp/crude soil, but it is not less than 1 m of its surface.

For providing for fire-fighting safety, it is necessary:

a) to produce periodic testing and the preventive inspections of fuel lines, hoses, reinforcement, instruments and equipment of fuel systems, without allow/assuming in this case leak and the inflows of fuel/propellant in points of connections and in equipment itself. The indicated inspections and revisions must be brought in in the log book of installations or bench journals;

b) the flushing of fuel and oil filters in gasoline or kerosene produce in gasoline purifying or in the separate isolated/insulated and fitted out for these purposes location;

c) with the possible overflows of fuel/propellant or oils the latter must immediately be removed with the aid of dry wood filings, after which the used filings must be removed from building into safe in fire sense place and burned;

d) to avoid sparking entire harvesting stock (shovels, scrapers, etc.) one should apply from the nonferrous metal, which eliminates sparking;

e) waste and fuels to store in closed tare, in this case their reserve must not exceed interchangeable necessity;

f) repair work on units with the application/use of the free flame (welding and other works) to produce little more than after obtaining of the corresponding resolution from the chief of experimental station and fire supervision;

g) in the locations of the possible accumulation of propellant vapors produce the periodic testing of the concentration of their content in air, without allow/assuming the formation of dangerously

explosive mixtures;

h) in each replacement from the workers of shop to have fire component/links (calculations) with precise distribution of responsibilities and actions on fight with inflammation or fire prior to the arrival of firefighting team.

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Chapter VII.

RECOMMENDATIONS REGARDING THE DESIGN OF EXPERIMENTAL STATIONS.

§1. Composition of experimental stations.

Depending on the conditions, scale and the character of production, experimental stations can be organized in the form of individual sections either department/separations, which form part of motor-assembling shop, or on the rights of independent shop. This is related both to series and to the experimental production of engines.

Territorial experimental stations depending on type of engine, its power and type of testing units can be arrange/located in the territory of the housing of motor-assembling shop; in the form of annex to it or they can be built in into this housing or in separate, independent housing.

If are allowed arrangement conditions of testing units, about which it will be said below, one should approach the arrangement of experimental station together with other shops. This reduces capital investments on construction unit and communications, it decreases the operational maintenance costs of buildings and the transport expenditures.

If necessary for isolation/insulation of experimental station from other shops, the safety and other reasons they are furnished in the separate, isolated/insulated, special annex, which adjoins the housing of motor-assembling shop, or they can be in it built in.

If necessary for more reliable isolation/insulation, and also, when testing units require the construction for them of special locations or isolated/insulated boxes, experimental stations can be placed in separate, independent buildings.

The selection of the method of the arrangement/permutation of experimental station is in principle important question, and it must be solved in each individual case taking into account concrete/specific/actual factors.

In general form, in the composition of experimental station can enter the following basic department/separations of service and the

sections:

1. Department/separation of training/preparation, which switches on the sections of the apron of engines, preparatory installation and their disassembly before and after testing.

2. Department/separation or sections of testing units.

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3. Department/separation or group of elimination of flaw/defects in engines, discovered during testing.

4. Auxiliary services and shop. Are this involved generator, shop mechanics, instrument, the ventilation, storerooms and others.

5.Everyday services and the locations of operating personnel.

Sometimes with experimental stations, there can be painter department/separation and expeditions.

The need for these department/separations of experimental stations is determined by the organization of production, by technological process and technical specifications for testing and

supply of engines in each specific case.

Thus, for instance, department/separation of sorting/partition is necessary only in such a case, when according to technical specifications is required the sorting/partition of engine after acceptance tests. In this case the department/separation of sorting/partition can be both with the assembly compartment or the shop and with experimental station. In the majority of cases, last/latter solution will be more expedient, since in this case engine after sorting/partition enters the monitoring test, which decreases its transportation.

Coloration more frequently is produced after testing. But there can be another order when the coloration of separate parts is produced to the assembly of engine. In this case painter compartment with experimental station is absent, while in expeditions is produced only tint in the form of the plotting of additional fresh thin paint coat.

The organization of expedition - the compartment of conservation and packing of engines and spare parts for them is necessary when plant supplies engines to side, to the client, territorial removed from factory. Under these facts expedition it is expedient to furnish with experimental station, in one with it housing.

Since the compartment: painter, sorting/partitions and expeditions are related along their technological airfoil/profile to the field of assembly-wiring and other shops, we do not consider it possible to dwell during these compartments.

§2. Arrangement of testing units.

Testing units can be furnished in common/general/total location for several testing units with partial isolation/insulation of the service personnel or installations themselves or in boxes.

In the latter case of testing, they are carried out in the separate isolated/insulated locations a the service personnel it is located in single or common/general/total for several devices in console rooms or the cabin/compartments of control.

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The arrangement of installations in the first two cases can be allowed under the conditions:

a) the safety control of the service personnel when during the test work of engine is eliminated the possibility of the emergence of fire, breakage of engine or breakaway from it of the separate rotating parts or units;

b) when the noise level of the operation during testing of braking devices and auxiliary mechanisms of stand will not exceed the maximum permissible noise levels, given in appendix 2.

Thus, for instance, stands of the tractor and similar to them engines of low and average power, which have silencers or the system of closed gas bleeder and not releasing in work of noise are more than it is shown above, usually they are furnished in common/general/total hall. An example of this arrangement is given in Fig. 25 and 26.

When the noise level in the rooms of experimental station with the general layout of the test benches is close to the maximum permissible level, can be applied isolation/insulation of the service personnel in the cabin/compartments of control or isolation/insulation of the test benches.

The first solution is expedient, when the cycle of one testing prolonged, and works for installation and disassembly of engine on stand and regulating-setup operations occupy relatively short time. In such a situation of businesses servicing operating personnel is located directly about unit short-term a long time during engine testing it it is located in the cabin/compartment of control, in the isolated/insulated from room noise. The general-arrangement diagram of this solution is given in Fig. 27.

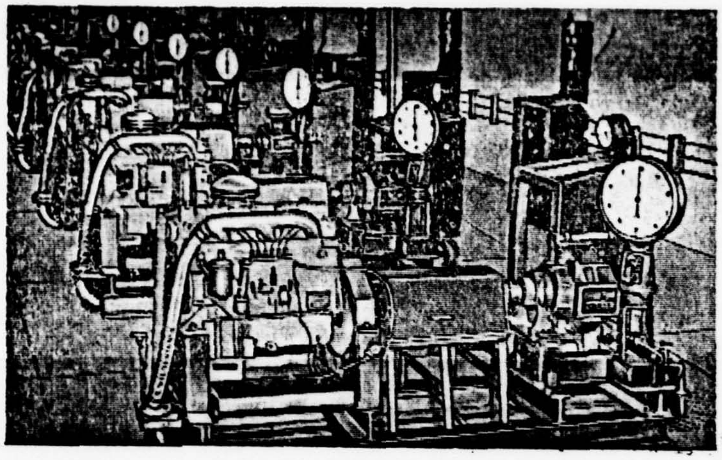

Fig. 25. General view of experimental station with arrangement of bench installations in common/general/total hall.

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The second version consists in the fact that the testing units from common/general/total hall are insulated by the sound-absorbing panel-partition/baffles in the form of separate cabins, in this case in the end part of the location and on to its top must be the apertures, sufficient for the supply of engines in room and their displacement/movement inside lifting-transporting devices. So.storony, to the opposite supply of engines, after partition/baffle is furnished the control panel, whence is conducted observation of the testing through the soundproofed window, arrange/located within

wall. In this case operating staff will be located under conditions considerably best, than with open devices both during testing and during installation and disassembly of engine. The schematic of the indicated layout is given in Fig. 28.

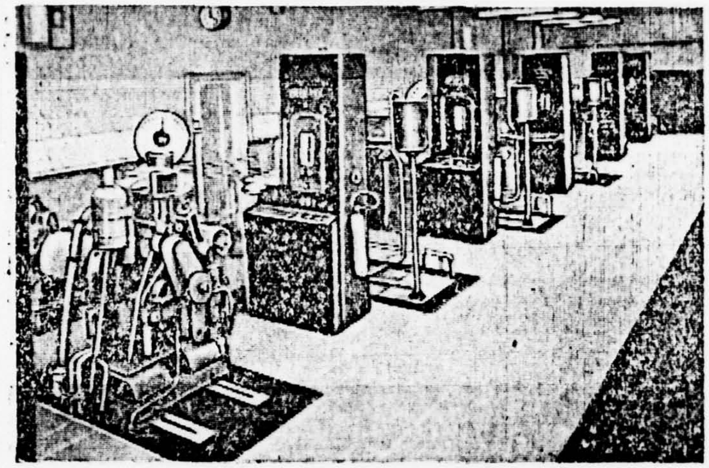

Fig. 26. General view of experimental station where walls and overlap of hall are coated with sound-absorbing panels (panels).

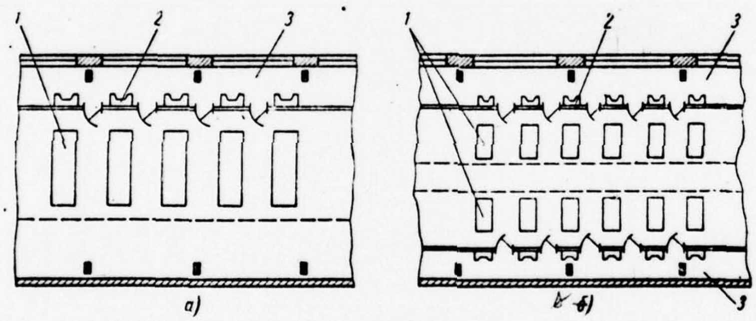

Fig. 27. Pattern of arrangement of experimental devices in common/general/total hall with fenced off cabin/compartments of control: a) with single-row arrangement of installations; b) with double-row arrangement of installations; 1 - test stands; 2 - control panels; 3 - sound-proofing compartment of control.

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In the case of the impossibility of safety control to the service personnel during test work or when it is not possible to lower noise level to the maximum permissible values, testing units must be furnished in the isolated/insulated locations, called experimental cabin/compartments or boxes. In this case the service personnel is furnished also in the isolated/insulated from box location - the cabin/compartments of control, whence is produced control, control and observation of tested engine.

The cabin/compartments of control can be common/general/total for several boxes or individual for each testing unit. The different general-arrangement diagrams of testing units are given in Fig. 29.

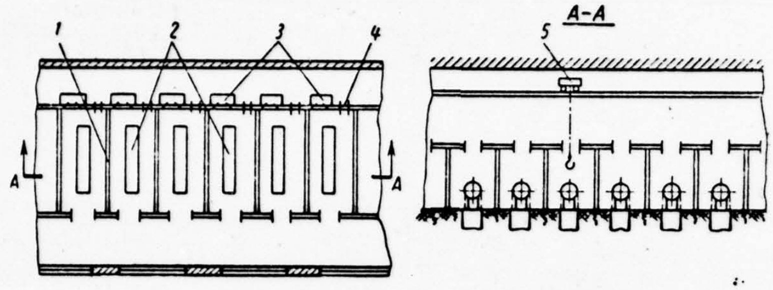

Fig. 28. Diagram of experimental station from partial noiseproofing: 1 - sound-absorbing panels; 2 - test benches; 3 - control panels; 4 - door; 5 - overhead-travelling crane.

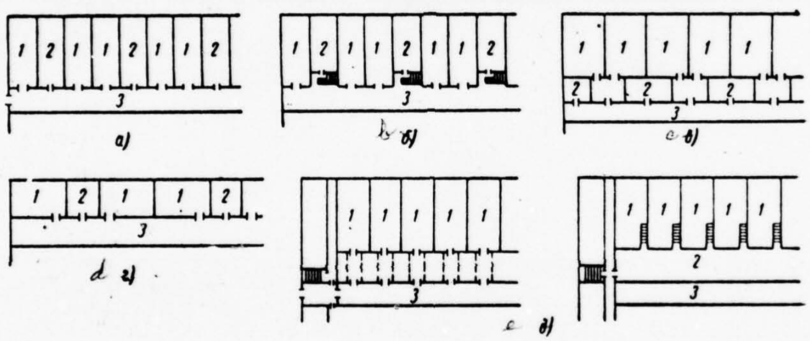

Fig. 29. Diagrams of boxes with different arrangement of cabin/compartments of control: a) side single-stage cabin/compartments of control; b) side two-story cabin/compartments of control. Under the cabin/compartment of control compartment of technological equipment and operating systems; c) the end, single-stage cabin/compartment of control; d) the end single-stage cabin/compartment of control with the longitudinal arrangement of boxes; e) the end two-story general cabin/compartment of control. **Under the cabin/compartment of control passage into box and the operating systems; 1 - box; 2 - cabin/compartment of control; 3 - passage.**

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In boxes compulsorily must be furnished stands of gas turbines and powerful piston engines where, besides high noise level, emitted during testing, can occur the breakage of the rotor disk of turbine, the breakaway of its blades, injectors or parts of the crankgear and other parts of engines. To the indicated piston engines one should relate such engines whose power exceeds 300-500 h.p., and also all engines of smaller power, but workers without silencers, with the open gas bleeder.

§3. Calculations of a quantity of stands, of work areas and states.

1. Labor intensity.

The labor consumption and the time, spent on the test work and all preparatory works, connected with their conducting at experimental station, are basic and main indices for determining the

required number of stands, of work areas and work force. These data are necessary not only for the order of required equipment, calculation of production, auxiliary and official-everyday areas, but also for the compilation of the various kinds of planned economic calculations and indices.

For the calculation of equipment and work areas the labor consumption usually is determined in machine-hours, while for the calculation of work force in man-hours.

Labor consumption is determined as a result of the technical normalization of technological process from each form of tests and other auxiliary activities, either by other methods: on the basis of the actual expenditures of time, on timekeeping, or by expert evaluation, the method of comparison of works with the available data on similar works, etc.

Technical normalization is usually produced by the laying out of entire technological process for the separate operations: to transfer/transitions and other cell/elements of works which are standardized.

During the calculation of equipment, of work areas and work force according to the effective norms to them, it is necessary to

introduce the correction factor, which considers the actual processing/treatment of these norms.

Labor consumption in machine-hours expresses the average duration of the determination of engine on stand taking into account time for its installation and disassembly, the production of regulating-setup works, the elimination of the small flaw/defects, produced on stand, the production of the necessary measurements during performance testing and calibration and the basic regime engine operation. Labor consumption in man-hours expresses the average expenditure of time in man-hours for conducting only of one testing or the production of other works, connected with the production of tests. It will depend on strength of crew, who operates one or several stands, and there can be less or more than the labor consumption, expressed in machine-hours.

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Thus, for instance, during crew, who consists of two people, and maintenance it one stand labor consumption in man-hours will be 2 times the more than labor consumption, expressed in machine-hours. If this crew services three stands, then labor consumption in man-hours with respect will compose 2/3 from labor consumption in machine-hours, etc.

2. Calculation of a quantity of stands.

The necessary quantity of stands or testing units at experimental station is determined from the formula

$$C = \frac{\Pi \cdot T}{\Phi}, \tag{31}$$

where C is the quantity of stands, rounded to integer to large side;

Π - the annual program of the production of engines, adjustable by planned target, in pieces;

П

T is total labor consumption of all tests, which are necessary on the average by one programmed engine, in machine hours;

Φ - the useful annual fund of output of one stand in machine hours.

If by experimental station is accepted one type of stand, then from formula (31) is determined the total required quantity of stands. In this case is determined the total labor consumption of all

types of tests, including prolonged, taking into account repeated tests which are necessary on the average by one programmed engine. The labor consumption of selective, commission and other endurance tests is determined by the division of the total annual labor consumption of these tests for annual program of issue.

The useful annual fund of output of one stand is the calendar operating time of stand per annum minus of losses, brought by machine, setup works and periodic calibration of the measuring system of the torsional moment and other devices of stand. This fund is determined from the formula

$$\Phi = B \cdot K, \tag{32}$$

where Φ is the useful annual fund of output of one stand in machine-hours;

B - the time of the calendar stand operation during one year on all replacements taking into account the reduced workday before output and holidays in hours;

K - the coefficient, which considers losses to repair, adjustment and the calibration of the equipment of stand. The value of this coefficient depending on a number of working replacements and type of installations is given in Table 4.

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If necessary of determining a quantity of work areas on the sections of the elimination of flaw/defects, installation and disassembly of engines, before and after testing and other works, the calculation of work areas is produced by formula (31). Since the labor consumption to these works usually is determined in man-hours, in this case it is necessary to consider the number of workers, simultaneously workers for this work area, by the introduction of the corresponding correction during the determination of the useful fund of output. So, with two workers on one work area of this fund will be 2 times more. Furthermore, for all manual work areas the coefficient, which considers losses, will be higher than at testing units, and it one should accept within limits of K = 0.97-0.98 of outside dependence on the number of replacements.

3. Calculation of states.

The calculations of the necessary authorized strength for completing of predetermined program of production consist in the

determination of production and auxiliary working, technical-engineering workers (engineering and technical personnel), computing and administrative-economic personnel (MAC) and the low-order service personnel (MOP).

A required quantity of production workers is determined by calculation. Entire remaining personnel is accepted according to regular schedule or according to standard data depending on the number of production workers. The calculation of the latter is produced by formula (31) during following changes in the separate values, entering this formula:

labor intensity is accepted in man-hours; the fund of output of equipment is replaced by the useful fund of output of one worker.

The useful fund of output of one worker is determined by means of the multiplication of calendar time in work into one replacement for year for the coefficient, which considers the losses of operating time as a result of nonappearance for work on valid reasons and time for annual leave.

Table 4. Value of the loss factor for the calculation of the useful fund of the time of output of equipment.

(1) Число рабочих смен испытательной станции	(2) Значение коэффициента K	
	(3) для электротормозных установок	(4) для гидротормозных, индукторных, комбинированных и прочих установок
(5) При работе в одну смену	0,97	0,95
(6) При работе в две смены	0,96	0,94
(7) При работе в три смены по 6 ч каждая	0,93	0,91
(8) При работе в четыре смены по 6 ч каждая, или в три смены по 7 ч	0,91	0,90

Key: (1). Number of working replacements of experimental station. (2). Value of coefficient of K. (3). for electric brake installations. (4). for the hydraulic-brake, induction, combined and other installations. (5). In work into one replacement. (6). In work into two replacements. (7). In work into three replacements on 6 h, each. (8). In work into four replacements on 6 h, each, or into three replacements on 7 h.

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These planned losses they are from 7 to 11o/o of entire calendar time depending on the duration of tempering.

On the average for experimental stations these losses can be accepted in size/dimension of 9o/o, whence the loss factor in this

case will compose K - 0.91.

Entire remaining personnel of experimental station usually is determined according to standard indices in percentages from the number of production workers.

Depending on conditions, scale and the character of production, standard indices can be establish/installed for each concrete/specific/actual production. For the amalgamated calculations it is possible to use data given in Table 5, obtained on the basis of the analysis of states of test stations the number of the foremost enterprises of machine-building.

§4. Calculation of required areas.

The total area of experimental bench as shops or its compartments is composed of:

a) the production area, occupied with directly experimental benches, equipment, the power-supply systems and maintenance, with the sections of the elimination of flaw/defects, with preparatory installation and dismantling of engines, etc., including passes and

the passages, arrange/located within the limits of production area;

b) the auxiliary area, occupied by shops and services, by storeroom, transformer vaults and by electrical distribution and converters, by the ventilation chambers, etc;

c) administrative-everyday locations, designated for the arrangement/permutation of cloakrooms, sanitary units and other everyday devices, locations for technical-engineering personnel and the employees of experimental station.

Table 5. Authorized strength on the categories of personnel in percentages from a quantity of production workers.

(1) Наименование персонала по категориям	(2) В % от количества производственных рабочих при числе их до:			
	(3) 50 чел.	(3) 100 чел.	(3) 200 чел.	(3) 400 чел.
(4) Вспомогательные рабочие	40	34	30	27
(5) Инженерно-технический персонал (ИТР)	20	18	16	15
(6) Счетный и административно-хозяйственный персонал (САХ)	15	13	12	11
(7) Младший обслуживающий персонал (МОП)	3,5	3,0	2.5	2.0

Key: (1). Designation of personnel on categories. (2). In o/o from a quantity of production workers with their number to. (3). man. (4). Auxiliary workers. (5). Technical-engineering personnel (engineering and technical personnel). (6). Computing and administrative-economic personnel (MAC). (7). Low-order service personnel (MOP).

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In the common/general/total area of administrative-everyday locations, usually is connected the area, occupied by staircases, passes, reels, which are found within the limits of these locations in the form of annex or internal partitions.

Production area is determined by the size/dimensions of the locations, necessary for the arrangement/permutation of stands,

brakes and other testing units as a whole, testing units as a whole, including auxiliary technological equipment, control panels, and also by the area of the necessary passes and passages. Preliminarily this area can be determined by the combined standard indices and subsequently it is refined with final planning. As a result of the varied conditions of engine testing, which are distinguished between themselves by power, designation/purpose, and the possibilities of a selection of the type of testing units, are large difficulties for the creation of single union norms. Since this area is determined by the type of the taken testing unit and by its dimensions, can be proposed formula for the approximate computation of the area, occupied by one testing unit in common/general/total hall or in boxes taking into account area for the room of control panel, but without shop passages and the areas, occupied by the apron of engines, by their installation and dismantling:

$$S_1 = K_1 (l + 2)(b + 2) \text{ м}^2, \qquad (33)$$

where S_1 - the area, occupied directly by one testing unit, in m^2;

K_1 - the coefficient, taken on Table 6;

l — the maximum length in the protruding parts of the unit, including stand with tested engine and brake group, in m;

b is the greatest width on the protruding parts of the unit in m.

The production area of experimental station approximately can be determined by the formula

$$S_2 = K_2 \cdot n \cdot S_1 \text{ м}^2, \quad (34)$$

where S_2 is the production area in m^2; K_2 is the coefficient, determined in Table 6; n - the number of testing units.

The value of quantities l and b is given above.

Table 6. Value of coefficients K_1 and K_2 for determining the area of testing units and production area.

(1) Наименование определяемой площади одной установки K_1 или производственной площади K_2 при расположении испытательных установок	(2) Значение коэффициентов	
	K_1	K_2
(3) Общей залы	1,2	1,75
(4) То же, но с изолированными кабинами управления	1,3	1,70
(5) Боксы с торцовыми кабинами управления	1,4	1,65
(6) То же, с боковыми кабинами управления	1,5	1,55

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When, on the station, several testing units of different types are present, the determination of area is carried out according to each group separately, and then areas are totaled. Formulas (33) and (34) are suitable for the amalgamated precomputations; subsequently the area, determined by them, is more precisely formulated with the planning of equipment.

For determining the common/general/total area of experimental station to production area, one should add auxiliary area and the area of administrative-everyday locations.

Auxiliary area is determined by the selection of the necessary services, connected with the provision for a normal operation of station. These services are usually furnished next to the production sections of station or in administrative-everyday annex, with the exception of gasoline flushing which must be arrange/located in the single-stage part of the building of external wall. The determination of auxiliary area can be produced on Table 7.

Table 7. Area of the auxiliary locations of experimental stations and laboratories of engines.

(1) Наименование помещений	(2) Расчетная общая площадь в $м^2$
(3) Инструментально-раздаточные кладовые	$0,1 \cdot p + k\sqrt{n}$
(4) Кладовые запасных деталей, вспомогательных материалов и спецодежды	$0,15 \cdot p + k\sqrt{n}$
(5) Мастерская механика цеха или ремонтной бригады . .	$0,22 \cdot p + k\sqrt{n}$
(6) Приборная мастерская и обменный пункт приборов .	$0,15 \cdot p + k\sqrt{n}$
(7) Маслокомната с хранением смазочных материалов . .	$0,20 \cdot p + k\sqrt{n}$
(8) Бензопромывочная	$0,08 \cdot p + k\sqrt{n}$
(9) Итого по цеху (отделению) . . .	$0,9\,p + 6\,к\sqrt{n}$

Note. Adopted in table designations:

p - list number of production workers;

n - the number of testing units;

k - the coefficient, depending on average power of the testing units:

(1) для установок средней мощностью (2) до 100 (3) л. с. $k = 4,0$;
» » » » (2) до 500 (3) л. с. $k = 5,0$;
» » » » (2) до 2000 (3) л. с. $k = 6,5$;
» » » » (4) свыше 2000 (3) л. с. $k = 8,0$.

Key: (1). for installations by average power. (2). to. (3). hp. (4). it is more than.

Key: (1). Designation of locations. (2). Calculated total area in m^2. (3). Tool-distribution storerooms. (4). Storerooms of spare parts, auxiliary materials and special clothing. (5). Shop mechanics of shop or maintenance crew. (6). Instrument shop and the exchange point/item of instruments. (7). oil room with storage of lubricants. (8). Gasoline flushing. (9). Altogether on shop (compartment).

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It is necessary to note that in the case of application/use at experimental station as braking devices of the electrical machines of direct current the area for the dynamoelectric hall or other converters is determined additionally, but Table 7 these areas is not considered.

The area of administrative-everyday locations is determined by the required state of experimental station. These locations can be only for an experimental station or are united with other shops and the compartments. Usually for convenience in the calculation during design the area of administrative-everyday locations defines taking

into account the area, occupied by passes, reels, stairs by cubicles the like, which, as all other areas, it is determined along the axes of building. The determination of everyday locations can be produced on Table 8.

Table 8. Area of the everyday locations of experimental stations and laboratories of engines.

(1) Наименование помещений	(2) Общая площадь на 1 чел. штатного состава цеха в $м^2$			
	(3) При работе в 1 смену	(4) При работе в 2 смены	(4) При работе в 3 смены	(4) При работе в 4 смены
(5) Туалетные комнаты	0,320	0,160	0,110	0,080
(6) Умывальники	0,036	0,018	0,012	0,009
(7) Душевые	0,490	0,245	0,163	0,123
(8) Гардероб, общая средняя площадь	0,520	0,520	0,496	0,485
(9) в том числе:				
(10) а) открытого типа	(0,070)	(0,070)	(0,046)	(0,035)
(11) б) индивидуальные шкафы, одинарные	(0,450)	(0,450)	(0,450)	(0,450)
(12) Курительная комната	0,030	0,015	0,010	0,008
(13) Комната для принятия пищи	0.18	0,120	0,080	0,060
(14) Итого в среднем на 1 чел. общего списочного состава округленно в $м^2$	1,58	1,08	0,87	0,77

Notes: 1. Table is comprised in connection with the sanitary norms of industrial design N 101-54 taking into account the required area to walls, passes, staircases and reels; therefore from it is determined the total area of everyday locations.

2. In the case of application/use at experimental stations of fuel/propellant with toxic additives (lead tetraethyl, etc.) area in shower and wardrobe locations is raised by 50o/o in view of need for organization of sanitary-washing point/item.

3. For small shops and compartments in the case of organization of independent everyday locations, their area can be increased in

following size/dimensions:

a) with common/general/total authorized strength of less 100 man/person - to 30o/o;

b) with common/general/total authorized strength from 100 to 150 man/person - to 20o/o.

Key: (1). Designation of locations. (2). Total area on 1 man/person of authorized strength of shop in m^2. (3). In work into 1 replacement. (4). In work into replacements. (5). Toilet rooms. (6). Wash-stands. (7). Shower-baths. (8). Cloakroom, total middle area. (9). among other things. (10). a) the open type. (11). b) the individual cabinets, single. (12). Smoking room. (13). Room for the acceptance of food. (14). Altogether on the average on 1 man/person of common/general/total workers on the payroll, it is rounded in m^3.

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The calculation of the area of administrative locations can be carried out on Table 9.

It should be noted that with a small quantity of testing units,

it is less than 3-4 pcs., and with respectively small states the composition of auxiliary, everyday and administrative locations sharply grow/rises with respect to production area. In these cases of area, one should determine from the sum of the minimally necessary locations taking into account unification or their cooperation with other production compartments or the shops.

Table 9. Area of the administrative locations of experimental stations and laboratories of engines.

(3) Наименование помещений	(1) Общий штатный состав станции (цеха)							
	(2) До 100 чел.		(2) До 200 чел.		(2) До 300 чел.		(2) До 400 чел.	
	(4) Полезная площадь в $м^2$	(5) Средняя удельная площадь на 1 чел. штатного состава в $м^2$	(4) Полезная площадь в $м^2$	(5) Средняя удельная площадь на 1 чел. штатного состава в $м^2$	(4) Полезная площадь в $м^2$	(5) Средняя удельная площадь на 1 чел. штатного состава в $м^2$	(4) Полезная площадь в $м^2$	(5) Средняя удельная площадь на 1 чел. штатного состава в $м^2$
(6) Комната начальника станции	10—15	0,2	15—20	0,14	20—25	0,12	25	0,10
(7) Комната секретаря	—	—	8—10	0,07	10—12	0,06	12—15	0,05
(8) Комната зам. начальника	—	—	10—12	0,08	12—15	0,07	15—20	0,07
(9) Планово-диспетчерское бюро	15	0,24	20	0,16	25	0,13	30	0,12
(10) Технологическое бюро	15—20	0,28	20—25	0,18	25—30	0,15	30—35	0,13
(11) Архив чертежей	10—15	0,2	15—20	0,14	20	0,11	25	0,10
(12) Комната отдела технического контроля	10—12	0,18	12—15	0,11	15—20	0,09	20	0,08
(13) Комната механика станции	—	—	12—15	0,11	15—20	0,09	20	0,08
(14) Контора станции	15—20	0,28	20—25	0,18	25—30	0,15	30	0,12
(15) Комната техперсонала цеха	12—15	0,22	15—20	0,14	20—25	0,12	25	0,10
(16) Комната представителей заказчика	10—12	0,18	12—15	0,11	15	0,08	20	0,08
(17) Комната общественных организаций	12—15	0,22	15—20	0,14	20—25	0,12	25—30	0,11
(18) Итого		2,00		1,56		1,29		1,14

Note. Middle specific area on 1 man/person of authorized strength includes also the area, occupied by passes, reels and staircases.

Key: (1). Common/general/total authorized strength (shops). (2). To man. (3). Name of locations. (4). Effective area in m^2. (5). Middle specific area on 1 man/person of staff in m^2. (6). Room of the chief of station. (7). Secretary's room. (8). Room the deputy chief. (9).

planning-dispatchers bureau. (10). Technological bureau. (11). Archive of drawings. (12). Room of quality control department. (13). Room of the mechanic of station. (14). Office of station. (15). Room of the technical personnel of shop. (16). Room of the representatives of client. (17). Room of public organizations. (18). Altogether.

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§5. Selection of the type and the arrangement of hauling means.

The solution to the question of the transport of engines at experimental station, selection and the equipment of it by hauling means will depend on:

a) the scale of production and program of issue, dimensions and weight of the transported engines;

b) the type of experimental station and method of the arrangement/permutation of testing units in the common/general/total hall of station or for the isolated/insulated boxes;

c) the need for the realization of intercrew or interdepartmental transportation.

For the supply of engines from assembly compartment to experimental station and further into painter compartment, expedition or to the section of the final assembly where is installed engine, can be used the following conveying devices:

1. Overhead continuously effective conveyors. This convenient and highly productive form of transport there will be advisable and it is justified only for mass production.

2. Tap/cranes, overhead-travelling crane or monorails with electric overhead conveyor, controlled from cabin/compartment or from sex/floor, can be used for series and small-scale production with limited distance of transportation. Tap/cranes and overhead-travelling crane it is expedient to apply only within one housing. Monorail with telpher can be used also for intercrew transportation; however, its operation in this case is connected with some inconveniences during the intersection of door apertures in buildings and the need for device in them of special gates or doors.

3. Standard or special electric cars and platform trucks with lifting stage, truck tractors with trailers and other forms of

trackless transport is very maneuverable and economical transport for large-scale, series and small-scale production. Are especially convenient and productive electro- and platform trucks with the lifting stage for the transportation of engines up to 3 t in weight. They do not require overloadings, since the engine is located on the support/socket from which it is transported, but lift and its dropping is produced by its own lifting stage. The transportation on them of engines can be produced directly to stand itself, which is especially valuable during the arrangement/permutation of testing units in boxes.

4. Rail transport of narrow or wide gauge for transportation on railroad either on special platforms by gasoline locomotives or on special self-propelled trucks. This is the bulky and complex form of transport, which occupies large area in buildings and in the territory, adjacent to station; therefore it can be justified only in the exceptional cases, for the transportation of very large in dimensions and weight engines.

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For the support for lifting-transporting operations, produced at experimental station on setting to the stand of engine and its taking after testing, it is frequently necessary to have additional hauling

means.

In the case of the arrangement of several test benches in common/general/total location for this purpose, are most convenient will be electrified tap/cranes and overhead-travelling crane, controlled, as a rule, from sex/floor.

For the testing units, arrange/located in boxes, in the majority of cases it will prove to be sufficient to equip them with monorails with the electric overhead conveyors, placed along the longitudinal axis of installations.

During the determination of the load capacity of conveying appliances, one should also consider the need for periodic lift and displacing the greatest over weight assembly of braking device during repair, preventive maintenance or the replacements of the parts of this equipment. If these operations, connected with the maintenance of brake rigging, entail an excessive increase in the load capacity of lifting-transporting devices, then it is expedient to search for ways of their execution with the aid of time/temporary removable rigging devices. For this purpose, for example, can be used the manual blocks and tackle of the necessary load capacity, temporarily hung to monorail or tripod. Monorail in this case is designed for maximum load capacity. This solution to question can give the

considerable savings of the capital investments in conveying devices and in the construction volumes of the locations of bench installations. Since an increase in the load capacity of constant conveying devices with the mechanical lift of loads and their movement, as a rule, requires an increase in altitude of building, in this case it is expedient to use time/temporary removable-rigging device. Furthermore, shortening the load capacity of bench conveying appliances gives large conveniences and maneuverability during the execution of basic production operations.

For setting and taking of engines from stand, they are are very convenient, but sometimes also are necessary the electric overhead conveyors, which have two rates of climb and dropping of loads. This special feature/peculiarity makes it possible to produce the more precise and smoother setting of engine in the setting places of stand without the scratch of obtaining impact/shocks or nicks. Requirement to two-speed transmission one should specify with the order of lifting-transporting equipment.

§6. Planning of equipment, systems of devices.

Before the compilation of the layout of the equipment of

experimental station, must be developed and solved a series of the basic production-engineering questions, connected with the organization of new or the reconstruction of the existing station.

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In this case, first of all and mainly these problems must be solved depending on the arrangement in it of basic equipment.

With the arrangement of testing units in common/general/total hall, they must be solved:

1. Method of transportation and the order of supply of engines to stands and back after testing for their further sequence.

2. Order of arrangement of stands and control panels to them, operating area/sites and passes between stands.

3. System of gas bleeder and diagram of its layout.

4. Selection of systems of centralized feeding of tested engines and stands themselves by fuel/propellant, by oil, water and so forth, location of communications and auxiliary devices.

5. Location of distributive, transformative and other electrical devices.

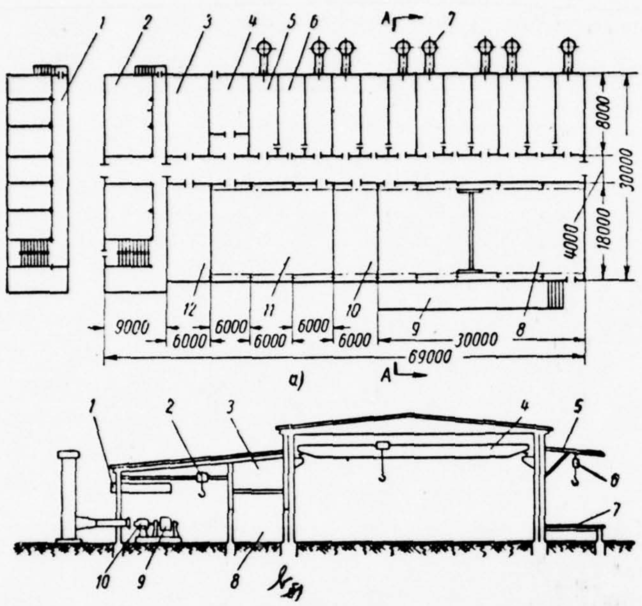

Fig. 30. Diagram of the planning of experimental station in separate housing for testing the gas turbines up to 1000 h.p. in power: a) the plan/layout for the housing of the experimental station: 1 - administrative-everyday annex, the second deck; 2 - the same, the first deck; 3 - oil room; 4 - gasoline flushing room; 5 - box of testing unit; 6 - cabin/compartment of control; 7 - vertical muffler on gas bleeder; 8 - location for conservation and packing of engines; 9 - loading footlight; 10 - generator; 11 - hall of training/preparation engine; 12 - shop mechanics and storerooms; b) the cross section of the housing: 1 - horizontal muffler of additional air; 2 - monorail with electric overhead conveyor; 3 - location of ventilation installations; 4 - electrical

overhead-travelling crane; 5 - mounting fixture above the loading footlight; 6 - monorail with electric overhead conveyor; 7 - loading footlight; 8 - passage; 9 - induction brake; 10 - engine.

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6. The same, ventilation-heating systems.

With the arrangement of testing units in boxes, they must be solved:

1. Outline/contour and the size/dimensions of box, the type of the cabin/compartment of control and its location.

2. Type and arrangement of devices of systems of air intake and gas bleeder, including sound-deadening devices.

3. Method of transportation and order of supply of engines in side, to stand and back for their further sequence.

4. Selection of systems of centralized feeding of tested engines and stands themselves by fuel/propellant, by oil, water and so forth, location of communications and auxiliary devices.

5. Location of distributive, transformative and other electrical devices.

6. The same, ventilation-heating systems and basic air ducts on box and cabin/compartment of control.

As an example of successful solution to the enumerated questions to Fig. 30 is given the diagram of the planning of experimental station for testing the transport gas turbines up to 1000 h.p. in power with the arrangement of testing units in the separate boxes, equipped with the sound-deadening devices.

On the experiment of building and operation of experimental stations, can be formulated the following basic recommendations, which one should consider with planning.

1. Planning with the arrangement of testing units in common location.

The location of testing units must abut the external wall of the housing of building and be furnished along it, in this case the

longitudinal axis of flight/span must be parallel to external wall.

This solution considerably raises fire safety of entire remaining housing, it improves airing the location of stands, it simplifies the task of the branch/removal of waste gases. If necessary for equipment by the sound-deadening devices, and also the supply of fuel lines it makes it possible to place the fuel lines of outside housing of external wall.

One should consider the possibility of the afterexpansion of experimental station either by means of annex from the end part of it of the basic flight/span of building, or by means of the transfer of the adjacent compartments, which do not have heavy and bulky equipment and complex production conduit/manifolds and other communications.

The test benches one should furnish perpendicular to the longitudinal axis of location, in one or two series with the passage between them. Stands for convenience in the installation of engines must be arrange/located by front to passage, and braking devices from it, to the walls of location. The distance between machines one ought not to accept less than 1 m.

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The selection of the width of passage depends on dimensions and the method of the transportation of engines and presence of contrary goods traffics. The width of passage can be sufficient within limits 2.5-4 m.

Under experimental station one should avoid the device of basements for the arrangement/permutation in them of ventilation installations, rooms for training/preparation of oils and other needs. Such basements do not make it possible to apply the standard projects of industrial buildings, considerably raise in price construction expenditures, they raise the explosive-fire hazard of experimental station and decrease the possibility of the subsequent reconstructions.

Oil room and ventilation installations can be placed next to the test benches, but if necessary for basement arrangement, are fenced off from them. For providing the oil drain, drainage or drainage oil tanks can be arrange/located in the local pit, sunk from floor level at the necessary depth, with the subsequent pumping from it of oil by pump.

2. Planning with the arrangement of testing units in boxes.

Between cabin part and other production and auxiliary services, one should provide for the passage, fenced off as far as possible by anechoic partition/baffles. The width of passage is determined by the dimensions of article and by conveying devices; however, less than 3 m made them should not be.

Boxes and testing units in them, as a rule, are furnished perpendicular to external wall or the longitudinal axis of station. During testing of piston engines brake group to more expedient establish/install is nearer to the external wall of box, and strictly the stand from entrance. Stands for gas turbines to more sometimes conveniently furnish vice versa; in this case the which is subject to testing turbine for an installation to stand is transported on top above the brake.

Devices of noise suppression and basic part of the gas-bleeding exhaust system must be furnished outside boxes of external wall, but air-inlet shaft/mines on boxes with vertical or horizontal arrangement.

The boxes, which have shaft/mines for the flow of air, which

goes to the feeding of engine and the ejection cf waste gases, must have calorific heating system. The ventilation chambers of the heating system and ventilation can be furnished on top above boxes; between them, next to the cabin/compartment of control; above the transition passage; or above the cabin/compartment of control.

The side arrangement of the cabin/compartment of control in comparison with end (see Fig. 29) gives the following advantages: best survey/coverage of an entire testing unit, including brake of group; shortening the technological communications, including controls and measuring systems; the closer and more convenient arrangement of testing unit provides the possibility of the best maintenance and cabin lighting of control of daytime, natural light; it improves the supply of fuel and other industrial communications it provides convenient entrance and the supply of engines into box.

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The side cabin/compartments of control it is expedient to accept with narrow and long boxes with their arrangement/permutation on the first or second decks. Two-story arrangement/permutation is conveniently during the highly available testing units. In this case under the cabin/compartment of control, one should place equipment and equipment for technological power-supply systems.

To shortcomings in the side cabin/compartments, one should relate that the fact that them they can service only two adjacent boxes; they lengthen the front of experimental station and they respectively increase the area of building approximately to 8-12o/o against end cabin/compartments.

End cabin/compartments can be arranged with wide boxes or with their arrangement on the second deck. In the first case wide box makes it possible to organize passage into box and to place next to it the cabin/compartment of control, in the second case the passage can be arrange/located under cabin/compartment. This last/latter solution makes it possible to have the common/general/total for all installations cabin/compartment of control, which gives a series of organizational conveniences and economic advantages in the maintenance of station.

Since in the cabin/compartments of control are placed many precise and fine/thin measuring meters, they must have the pure/clean, bright, convenient and beautifully designed locations.

The supply of energy and technological communications for the feeding of separate users can be produced where this allow conditions

in underground channels, for columns, walls and under the ceiling overlap of building. One should avoid device for these purposes of passage channels - the complex and expensive constructions, which prevent the application/use of standard buildings and standard structures. For communications with lower separation, including those that require gradient/drafts and drainages, it is possible in the majority of cases tc manage with underground channels. According to the considerations of control, revision and possibility of the packing of the additionally required communications, these channels must have stripper plates.

§7. Construction characteristic of buildings.

The construction characteristic of the buildings of experimental stations in many respects depends on the type of the engines, tested of their power, and the type of testing units. For stations with the arrangement of testing units in common/general/total location its structure will not differ from common industrial single-story buildings. In this case for the more convenient use of hauling means experimental station to more preferable furnish in single-span building.

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The width of flight/span according to the available standard farm/trusses can be accepted by 12, 18, 24 m and more with the space of the columns through 6 or 12 m. It is expedient in this case to have to the riding-crop of the arrangement of columns, one-type with other flight/spans, available in this housing of building. The selection of the necessary height/altitude will depend on the dimensions of testing units and engine, and also on the methods of transportation, constructions of lifting-transporting devices and their load capacity.

If necessary for the arrangement of testing units in the isolated/insulated cabin/compartments or boxes, the latter in construction sense can be those built-in into standard design of the flight/span of industrial type building as annex to it or in the form of separate building. When selecting possible solutions, it is necessary to consider the sound-proofing abilities of walls, overlaps, door and window apertures, and also vibration isolation from the test pits of the remaining part of the building where is arrange/located experimental station.

The structures of the building of experimental station as a whole and of its separate locations must satisfy norms and the requirements which are related to the category of these

constructions, according to classification in appendix 3.

The auxiliary locations, which require partitioning of remaining sections (shop, storeroom and other locations), and also administrative and everyday locations can be furnished in separate annexes or be built in into the production volumes of buildings. It is expedient so that these annexes or available partitions indoors would not fall on height/altitude outside the dimensions of basic building and they were not more than 2-3 decks.

During the construction of experimental stations, must be directed special attention to the following special feature/peculiarities of some structures.

1. Foundations under equipment.

In order to eliminate the transmission of vibrations from engine on, the foundations of the test bench, including brake group, they must have a breakage from surrounding constructional structures of building. As allows the experiment of the carried out tests of powerful and especially slow piston engines (engines of more than 500 h.p. on rated r/min of less 2000 r/min), it is very desirable under

such testing units to make foundations on the elastic support. The diagram of this foundation is given to Fig. 31. In this case, it is necessary that the foundation would have sufficiently large mass of concrete, and for an increase in strength - reinforcing as metal. The bottom of this foundation must be arrange/located below the base/root of the foundations of the surrounding structures of building.

For gas turbines - machines more balanced and high-speed whose natural vibration frequency is sufficiently high in comparison with the frequency the surrounding structures, it is expedient in boxes foundations to make in the form of power sex/floor.

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The diagram of this foundation is shown to Fig. 32. From technological point of view, this foundation has great possibilities on the case of a change in the unit, the need for setting of accessories, etc.

All bench foundations must have laying cell/elements from the metallic busbar/tires, packed in the body of foundation, as shown in Fig. 31 and Fig. 32. This it frees from the need for application/use for the complex in manufacture, bulky and expensive cast iron plate/slabs, which did not justify itself in practice.

All foundations must be packed so that their upper bottom would be flush with the sex/floor of the location of testing unit. This packing eliminates small rapids and creates conveniences in operation, during approach and maintenance of stand.

As the cushions can be applied the bundles from several layers of the asbestos, covered in pergamyn, the plate/slabs from plug, the plastics, which do not lose elasticity with aging, and other elastic materials.

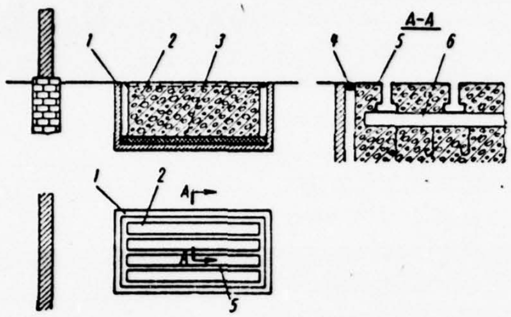

Fig. 31. The diagram of foundation under the stand, isolate/insulated from the surrounding constructions of building on the cushion: 1 - duct of foundation; 2 - foundation; 3 - cushion; 4 - elastic packing/seal; 5 - busbar/tire for fastening of bench equipment; 6 - stressed frame.

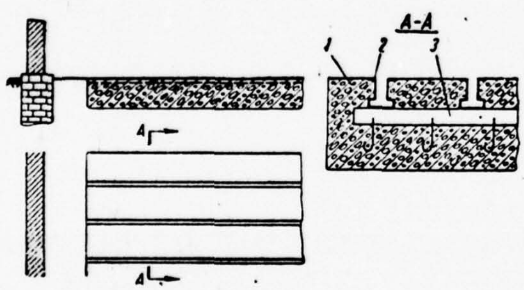

Fig. 32. The diagram of foundation in the form of common/general/total thrust plate for several testing units: 1 - array of foundation; 2 - busbar/tire for fastening of equipment; 3 - stressed frame.

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In boxes for testing the different engines by the power of more than 500-800 h.p. the structures must have a breakage of vibration insulating welds from the cabin/compartments of control and remaining structures of building. A similar vibration isolation is extremely necessary for the cabin/compartments of control, arrange/located on the second deck. Is reached it by device either double walls or the columns on which rest the adjacent the box constructions. In this case, the walls or columns must have the single foundations, isolate/insulated from the foundations of the walls of boxes. For providing the strength of the structures of the walls of boxes, they can have packing reinforced-concrete belt/zones or even the reinforced-concrete framework/body, filled with brickwork.

2. Constructions weeding.

The selection of optimum constructions weeding for experimental stations it has large value. Good construction weeding is especially necessary when basic transportation is realize/accomplished on

sex/floors with the aid of electric car, the truck tractors with the trailers and of other forms of trackless transport. The premature wear of insufficiently fail-safe designs weeding it impedes, and it sometimes also deranges tests such weeding and dust has adverse effect on the quality of the operation during their testing.

For the indicated reasons for experimental stations, common cement hems cannot be recommended.

Asphalt or asphalt-concrete coatings weeding are also unsuitable due to their capability for dissolution with the frequent incidence/impingement on them of gasoline, kerosene and other hydrocarbon fuels and oils. These hems also do not make it possible to support purity/finish indoor of station. Xylolite hems or hems from the xylolite pressed slabs are also unsuitable for production locations as a result of their insufficient strength; however, they can successfully be applied for the coating of administrative, auxiliary and certain part of the everyday locations where there are no moisture and large evaporations.

Hems from metallic slabs are not capable of withstanding large loads from trackless transport and are completely unacceptable due to their large slip especially with the incidence/impingement on them of oils or liquid propellants. Therefore such hems at experimental

stations can be applied partially: for the cabin/compartments of control, laboratory locations and sanitary assemblies in everyday locations.

From those who exist weeding most acceptable for all types of experimental stations they are mosaic hems (marble grit). Such hems are suitable both for the coating of all production locations and for passages, passes, engine houses, etc.

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For providing the more high wear resistance a series of the existing experimental stations forced were to cover the hems on the sections of the basic transportation of engines with the metallic, cast iron plate/slabs, having corrugated surface. As it shows the practitioner of work, such constructions are very strong and reliable in prolonged operation.

3. Finishing works.

The internal finishing of the production locations of experimental stations is determined by technological requirements in

the part of the observance and maintenance in them of the necessary purity/finish. Thus, for instance, gas turbines during testing require the increased purity/finish of the air, which enters the combustion chamber from the locations of experimental station. In this case it is not allow/assumed so that in it would be dust or particles of building materials. The used electrical machines and electric motors for brakes and converters also require the maintenance of the purity/finish of the locations where they are arrange/located. Therefore the majority of testing units requires, in order to the internal surface of locations, including the cabin/compartments of control, it would be plastered, but on entire perimeter of walls, on height/altitude from sex/floor on 2-2.5 m they would be arranged the panels, painted by oil paint. The metal constructions of overlaps, conveying appliances, the monorails, the crane runways, ventilation metallic air ducts and so forth must be also painted by oil paint or nitrocellulose enamel. The remaining structures of walls and ceiling overlaps can be painted by distemper.

If the internal surface of walls and partition/baffles is cover/coated with the sound-absorbing facing, then these surfaces are not plastered and finishing coatings they do not undergo.

Finishing remaining auxiliary administrative and everyday locations is fulfilled according to the effective norms.

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Chapter VIII.

NOISE SUPPRESSION OF EXPERIMENTAL STATIONS.

§1. Sources of noise and fight with them.

During the test work of a series of engines and their assemblies, appears the intense noise, which creates heavy hygienic working conditions not only to the personnel, which operates testing units, but also to the workers of adjacent shops. Being spread to large distances, this noise is serious interference/jamming, also, for all, that live in area of the arrangement of experimental station or laboratory.

The prolonged stay in the zone of action of loud noise is led to the damage of the normal activity of central nervous system. In this

case, is depressed the labor productivity, is retarded reaction to the sound and other signals, is attenuate/weakened attention, which contributes to an increase in the traumatism and to occupational diseases. The noise of high level is harmful also for a hearing aid, since it causes partial, and sometimes also the total loss of audition.

By most irritating are noises in the frequency region 700-1000 Hz and especially higher 2000 Hz. Therefore the contemporary experimental stations and the laboratories whose units separate high noise level, are unthinkable without the realization on them of the measures of noise suppression and soundproofing.

Sanitary-engineering norms and the requirements for state sanitary inspection establish/install the maximum permissible noise levels in production (see appendix 2). These norms require also the presence of a santary-shielding zone between experimental stations, their separate units or laboratories and habitable houses, culture-and-welfare services and the constructions which can be located in area of their arrangement. A radius of the sanitary-shielding zone is determined 300 m. The sound-deadening devices must ensure beyond the limits of this zone noise level not more than 70 dB (at the average and high frequencies). Sometimes the radius of the stanitary-shielding zone can be abbreviated/reduced to

100 m under provision condition after this zone noise level indicated above of maximum.

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Noise sources during testing of piston engines are issue of waste gases, work of mechanisms as a result of motion and friction of gears, knock of the valves, springs, cams and other parts, and also noise, emitted by the vibration of crankcase, frame and connecting tubes. However, the greatest noise level originates from gas outlet and partially from air-intake as a result of the outflow of gas and air and jump in pressure in exhaust and admission ports and conduit/manifolds. Common/general/total noise level and the characteristic of its spectrum in frequencies of piston engines depends on power, the number of cylinders, revolutions and other design features. Of the majority of engines of this type, the noise spectrum is composed of the frequencies, affecting its level and arrange/located within limits from 100 to 4000 Hz; in this case the highest level of noise give the frequencies from 200 to 600 Hz.

During testing of piston engines with the closed issue of waste gases and especially with the silencers of engine the noise level sharply descends. A decrease in this level in larger measure occurs at high and medium frequencies.

In work of gas turbines, the noise formation occurs mainly because of the turbulent mixing of the particles of gas jet, coming out from turbine at a high speed, together with the particles of surrounding air. Of gas turbines to noise level and its frequency characteristics, has effect also work of compressor, turbine, combustion chamber and drives of the operating mechanisms.

The frequencies, component the ground level of the noise of these engines, are located in the spectrum from 100 to 8000 Hz, of them the greatest level give the frequencies from 200 to 1000 Hz.

If the rate of the coming out gas at values of more than 100 m/s affects the intensity of noise, which is velocity function in the eighth degree, then temperature of gases intensity affects insignificantly.

§2. Basic concepts and the determinations of noise.

The technological level of contemporary in the majority of cases makes it possible to solve in a sufficient measure all questions,

related to silencing of testing units. Many of these questions can be solved on places by very workers of experimental stations. For the possibility of the solution to the applied problems, connected with subsequent calculations of the sound-deadening and sound-proofing devices, we give from acoustics some basic concepts and determinations.

Noise is a complex sonic process with the rich spectrum. Some noises contain the sounds of percussive character (momentum/impulse/pulses).

Sound pressure - the difference between the instantaneous value of the continuously changing sound-wave pressure and the constant atmospheric pressure, which exists at the particular point in the absence of sound.

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Force or intensity of sound - the quantity of sound energy, which passes per unit time through the unit of area/site, perpendicular to direction of its propagation. Sound intensity is equal to

$$I = \frac{P^2}{\rho \cdot c} \text{ эрг/см}^{2(1)} \cdot \text{сек}, \quad (35)$$

Key: (1). erg/$cm^2 \cdot s$

where P is the sound pressure in dyn/cm^2; ρ - the density of medium in g/cm^3; for standard air

$$\rho = 1{,}21 \cdot 10^{-3} \overset{(1)}{г/см^3};$$

Key: (1). g/cm^3

c - the sound propagation velocity in this medium; in air under normal atmospheric conditions this speed is equal to 3.43×10^4 cm/s.

During a change in the temperature of air, the speed of sound is defined as:

$$c = 18{,}3\sqrt{T}\ \overset{(1)}{м/сек}, \qquad (36)$$

Key: (1). m/s

where T is absolute temperature of air in °K.

Sound intensity level In acoustic engineering it is accepted to estimate intensity of sound or sound pressure more frequent not in absolute, while in relative logarithmic units - decibels. The measured thus values they are called levels. The sound intensity level is tenfold, common logarithm of the ratio of actual sound intensity at the particular point of space to threshold sound

intensity:

$$L = 10 \lg \frac{I}{I_0} = 20 \lg \frac{P}{P_0} \text{ дб,}^{(1)} \qquad (37)$$

Key: (1). dB, where I is th esound intensity at the particular point of space; I_0 the sound intensity, which corresponds to the conditionally taken zero level (threshold of audibility), equal to

$$I_0 = 10^{-16} \text{ вт/см}^2{}^{(1)} = 10^{-9} \text{ эрг/см}^2 \cdot \text{сек}^{(2)}$$

Key: (1). W/cm². (2). erg/cm²•s

(it approximately corresponds to intensity hardly audible sound in the frequency domain of the greatest sensitivity of audition);

P - sound pressure at the particular point of space in dyn/cm² (bar) corresponds to sound intensity I;

P_0 - sound pressure in threshold sound intensity, corresponds to sound intensity I_0, in this case the sound intensity level equal to 1 dB, corresponds to sound pressure.

$$P_0 = \sqrt{\rho \cdot c \cdot I_0} = 2 \cdot 10^{-4} \text{ дин/см}^2{}^{(1)} \approx 2 \cdot 10^{-4} \text{ бар}^{(2)},$$

Key: (1). dyn/cm². (2). bar.

i.e. corresponds approximately 0.0002 bar or 2•10 ¹⁰ atm.

Loudness level - the subjective quality of auditory perception

depends not only on sound intensity, but also on frequency, or on the conditions of perception and duration of effect.

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For the quantitative comparison of volumes of sound of different frequencies, there is a concept of the loudness level, the unit of measurement of which is background. Regarding the loudness level in backgrounds numerically it coincides with the sound intensity level in decibels at frequency 1000 Hz. For the sound whose level below 90 dB, at frequencies below 1000 Hz the absolute value of the scale in backgrounds numerically lags behind decibel scale. At frequencies higher 1000 Hz on the same level of sound, on the contrary, the absolute value of scale in decibels of level of sound, on the contrary, the absolute value of decibel scale numerically lags behind the scale in backgrounds. For loud sounds above 90 dB it is possible to count that the loudness level does not in practice depend on frequency and coincides with the sound intensity level

Minimum that which is received by audition a change in the sound intensity composes approximately 10o/o, which, in turn, corresponds approximately to 1 dB.

During the comparison of sounds of different intensity, it is

necessary to keep in mind that the difference on 10 dB on the levels of sound above 60 dB is absorbed by audition approximately as double difference on volume.

Frequency - the number of oscillation/vibrations in of seconds, is expressed in hertzes. Interval into one octave corresponds to frequency doubling. Practical interest for applied acoustics have seven octaves from 32 to 4096 Hz (from 32 to 64 Hz; from 64 to 128 Hz and so forth). the greatest role in this range have frequencies from 100 to 3200 Hz. This is explained to the facts that the sensitivity of the hearing aid of man at not very large sound intensities is low at frequencies to 100 Hz and it is great at frequencies 1500-2000 Hz.

For piston engines fundamental frequency can be calculated by the formula

$$f_1 = \frac{n_1 \cdot i}{n_2 \cdot 60} \text{ гц}^{(1)}, \qquad (38)$$

Key: (1). Hz.

where n_1 is a speed of the crankshaft per minute; i - the number of jugs; n_2 - speed, which are necessary to one working course (cycle/stroke).

respectively for gas turbines fundamental frequency will compose

$$f_2 = \frac{n \cdot i}{60} \text{ гц}^{(1)}, \qquad (39)$$

Key: (1). Hz.

where n is a speed of the shaft of turbine (compressor per minute; i - the number of blades of turbine (compressor).

However, it is necessary to keep in mind that for these fundamental frequencies will be superimposed other, irregular frequencies whose origin is caused by the turbulent eddy-like flow of waste gases, through the gas-bleeding channel at high speeds. Therefore the noise spectra of these engines will consist also of other frequencies.

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§3. Methods of the smothering of noise.

Special measures for noise reduction cn experimental stations and laboratories during the provision for the tolerance levels beyond the limits of sanitary-shielding zone are reduced to the solution of the following basic problems:

1. Noise reduction indoor of the testing units way reducing of

of internal surfaces of building with sound-absorbings material. This method can be applied only when the noise level, isolated by testing units, is relatively small, since it can ensure its reduction/descent not more than 5-10 dB. furthermore, the effectiveness of this method depends also on size/dimensions and the relationship/ratio of the dimensions of the supressed location.

2. Arrangement/permutation of testing units in isolated/insulated boxes with device of bench silencers is most efficient means on reduction/descent in noise. During operation of such installations, the service personnel is located in the isolated/insulated from noise cabin/compartments of control.

Virtually this method does not have any limitations and therefore it is suitable for all engines in question, including those that separate the highest noise levels.

3. Soundproofing of adjacent with testing units locations for providing in them acceptable noise levels.

In measures for a reduction/descent in the noises at experimental stations, it enters:

a) determining the noise engine characteristic during its bench

tests;

b) the determination of the maximum permissible values of the noise level outside building, of the channels, which are imparted with atmosphere, in immediate proximity of them, and also in adjacent with unit locations;

c) the determination of the effectiveness of silencers and sound-proofing ability of walls, partition/baffles, doors and windows for isolation/insulation of adjacent locations;

d) the selection of the type and diagram of silencers;

e) preliminary hydraulic design and the determination of basic sections from the channel of silencer;

f) acoustic calculation with the selection of constructing the sound-deadening and sound-proofing cell/elements and the determination of their basic dimensions;

g) the construction of silencers and the refinement of hydraulic designs;

h) manufacture and building experimental model of silencer;

i) testing in nature, finishing and the correction of drawings, manufacture and building the batch of silencers.

The noise engine characteristic are determined by means of full-scale measurements, if these data they are absent.

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Noise level are measured with the aid of objective of noise meter (Sh-1, Sh-52 and others), but frequency spectra and the levels of noise according to them - with the aid of analyzer or audio-noise meter with fitted out to it band-pass filter. These measurements are produced by their forces or with the aid of of noise metering stations. State sanitary inspection or other organizations.

As an example for tentative comparisons Table 10 gives given data on common/general/total noise level and the frequency band of some engines.

The maximum permissible values of noise level are determined from calculation. During propagation by air, the noise is lost to the atmosphere. Therefore noise level of the sound-projecting section/cut

can be higher than this is required on the boundary/interface of the sanitary-shielding zone. The permissible common/general/total noise level $L_{\partial on}$ at the emitting section/cut (outside building) of testing unit after silencer can be determined by the formula of I. K. Razumova

$$L_{\partial on} = 78 + 20\lg \frac{r}{\sqrt{S}} - \Delta \overset{(1)}{\partial 6}, \qquad (40)$$

Key: (1). dB.

where r is a distance from noise source to the boundary/interface of the sanitary-shielding zone in m; S - the cross-sectional area, emitting noise, in m²; Δ - correction for the number is simultaneous of the working noise sources with the different section/cuts S in dB; Δ are 10 lg n, where n - the number is simultaneous of working installations.

The maximally permissible values of the noise level in adjacent with testing unit locations are accepted according to time/temporary norms.

Table 10. Common/general/total exemplary/approximate noise level and the frequency bands of the operation of some engines in immediate proximity of them.

(1) Наименование двигателя	(2) Общий уровень шума в дб	(3) Диапазон основных частот в гц
(4) Автомобильный двигатель мощностью до 100 л. с. при работе на стенде с закрытым газовыпуском	85—95	100—4000
(5) То же, но при разрыве газовыпускной струи (полуоткрытый и открытый выпуск)	100—110	100—4000
(6) Автотракторный двигатель мощностью до 400 л. с. при работе на стенде с закрытым газовыпуском	100—110	100—4000
(7) То же, с открытым газовыпуском	110—120	100—4000
(8) Газовая турбина транспортного типа мощностью до 200 л. с. с открытым газовыпуском	115—120	100—8000

Key: (1). Designation of engine. (2). Common/general/total noise level in dB. (3). Range of fundamental frequencies in Hz. (4). Automobile engine up to 100 h.p. in power in work on stand with closed gas outlet. (5). The same, but with the breakage of gas-discharge jet (half-open and open issue). (6). Tractor engine up to 400 h.p. in power in work on stand with closed gas outlet. (7). The same, with that which was opened gas outlet. (8). Transport type gas turbine up to 200 h.p. in power with that which was opened gas outlet.

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The necessary effectiveness of the silencers or other

sound-deadening devices is determined from the formula

$$L_{гл} = L_{уст} - L_{доп} \; дб, \quad (41)$$

Key: (1). dB.

where $L_{гл}$ is effectiveness of silencer or sound-deadening devices, i.e., required value of smothering in dB; $L_{уст}$ is a common/general/total noise level emitted by unit, or the noise level indoor of testing units to smothering in dB; $L_{доп}$ is the common/general/total acceptable noise level of the emitting section/cut or indoor of testing units in dB.

The value of the soundproofing of walls, partition/baffles, windows, doors and other is defined as difference between the noise level indoor of testing units and the tolerance level in adjacent with it locations, from the formula, similar preceding/previous,

$$U_{тр} = L_{уст} - L_{доп} \; дб, \quad (42)$$

Key: (1). dB.

where $U_{тр}$ is the required average/mean sound-proofing ability of the enclosing construction in question.

Types and the diagrams of silencers in each specific case are selected optimum both from the viewpoint of the possibility of using of available material and location of silencer and minimum capital

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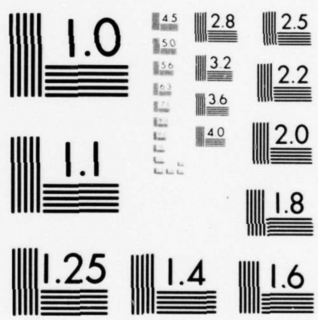

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investments. Separate recommendations according to types and diagrams of silencers are given below.

Preliminary hydraulic design consists in the determination of the necessary section/cuts from the channel of silencer. These section/cuts will be determined by the flow rates of waste gas or its mixtures with air and the taken speeds of flow. Data on allowable speeds for separate materials and silencers are given below.

The acoustic calculations, convenient for a practical use during the calculation of some silencers still created at present. Theoretical calculations require special knowledge, are complex, cumbersome, and not always give precise results mainly due to the absence of many initial data, required for such calculations. However, in a number of cases by acoustic calculations, although and approximately, it is possible to base the basic dimensions of the sound-deadening and sound-proofing devices.

§4. Sound-absorbings material.

the materials, which possess the ability to actively absorb the incident on them from without acoustic waves, they are called

sound-absorbings material. They include the porous materials in pores of which acoustic waves cause oscillations of air, and therefore as a result of internal friction the sound energy of oscillations partially is converted into thermal.

The effectiveness of the absorbing properties of such materials is characterized by the coefficient of sound absorption α. By this coefficient they imply quotient of the division of the sound energy, absorbed materials, into the sound energy, falling/incident to the surface of this material.

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The coefficient of sound absorption depends on the properties of material, on the degree of porosity, the size/dimension of pores, frequency of sound, thickness of material and angle of incidence in the sound. The majority of sound-absorbings material has the higher coefficient of the absorption on of average/mean and high frequencies and certain decrease in it at low frequencies (below 200 Hz).

Sound-absorbings material are applied for form boards for the purpose of noise reduction in separate locations, and also in the device of silencers. For the indicated target/purposes most effective are fibroporous materials, which include fiberglass, mineral wool,

departure/withdrawals of kapron filament, slag wool, knock, oakum, etc.

Furthermore, sometimes can be also used bulk materials, although possessing the lower coefficient of sound absorption, then cheaper and are more available, more than such, as pumice grit, brick grit, small crushed metallic shavings, and others.

Raw materials go mainly to the manufacture of sound-absorbing panels or are applied in the form of packing in the sound-deadening cell/elements the second - both in loose form and in granulated-connected form, in the form of acoustic plate/slabs, blocks, etc.

Fibrous and friable sound-absorbings material require the use of protective clothing in the form of glass cloth, of wire gauze and perforated/punched sheet material.

To soundproofing materials, used in the bench gas-bleeding silencers, are presented following requirements.

Life to the temperature conditions, accepted for the silencers of the issue of waste gases. Construction of silencer as a whole, including the sound-absorbing cell/elements, it must be made from

flameproof materials.

Life to vibrations and efflorescence, that occur under the effect of air-gas flow at the taken for it rated speeds.

Minimum hygroscopicity of all used sound-absorbings material and the biological life of the materials of organic origin.

In air-intake silencers, through which the air enters engines for fuel combustion, sound-absorbings material must not separate solid particles, dust and other mechanical impurities.

When selecting sound-absorbings material, it is necessary to apply the materials, which possess the high coefficient of sound absorption, which will make possible to reduce the length of the sound-deadening cell/elements and, consequently, also to entire construction of silencer.

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For the calculation of silencers and their subsequent substantiation Table 11 gives the characteristics of the coefficients of the sound absorption of the most commonly used materials both on the various frequencies and on common/general/total indices for all

frequencies.

An increase in the thickness of sound-absorbing material decreases noise in the range of low frequencies. The insufficient density of the packing of material in the sound-deadening cell/elements shrinks its, which produces a reduction/descent in effectiveness of silencer. The excessive density of packing leads also to a reduction/descent in this effectiveness. Experimental data the practitioner of the operation of the sound-deadening devices make it possible to recommend thickness of the layer to each side from 75 to 100 mm. In this case the density of the packing of sound-absorbing material, measured it by specific weight, must be:

(1) Стекловолокно, минеральная шерсть, шлаковая вата (диаметр волокон не более 15—20 *мк*)	150 *кг/м³* (2)
(3) Антипирированная хлопковая вата	50 *кг/м³* (2)
(4) Отходы капронового волокна	100 *кг/м³* (2)
(5) Пакля, очищенная от пыли и костры	120 *кг/м³* (2)
(6) Пемзовая крошка с размерами зерен 1,8—3,5 *мм*, просеянная и уплотненная на вибраторе	450 *кг/м³* (2)
(7) Кирпичная крошка, при тех же размерах зерен, просеянная и уплотненная	1150 *кг/м³* (2)

Key: (1). Fiberglass, mineral wool, slag wool (diameter of filaments are not more than 15-20 km). (2). kg/m³. (3). Antipyrized cotton cotton. (4). Departure/withdrawals of kapron filament. (5). Oakum, purified from dust and bonfires. (6). Pumice grit of grains 1.8-3.5 mm in size/dimension, of latter and condensed on vibrator. (7). Brick grit, with the same grain sizes, sifted and condensed.

Table 11. Value of the coefficient of sound absorption α for some sound-absorbings material.

(2) Наименование материалов	(1) Коэффициент звукопоглощения по частотам							
	106	212	425	850	1700	3400	6800	(3) Средний по всем частотам
(4) Шлаковая вата марки «150» Краснопресненского комбината стройматериалов. ГОСТ 4640-52. Объемный вес 150 $кг/м^3$, толщиной 100 *мм*	0,37	0,76	0,90	0,91	0,90	0,88	0,80	0,78
(5) То же, с защитным от выдувания слоем стекловолокна из АСИМ-9 толщиной 9 *мм*, закрытым стеклотканью. Общая толщина 100 *мм*	0,22	0,63	0,85	0,90	0,86	0,80	0,72	0,71
(6) Стекловолокно ⌀25 *мк* в пластинчатых или облицовочных глушителях	0,24	0,44	0,55	0,58	0,60	0,50	0,45	0,48
(7) Отходы капронового волокна в пластинчатых или облицовочных элементах глушителей	0,26	0,44	0,52	0,57	0,60	0,50	0,45	0,48
(8) Строительная пакля в пластинчатых или облицовочных элементах глушителей	0,36	0,61	0,82	0,87	0,90	0,78	0,60	0,70
(9) Антипирированная вата в пластинчатых или облицовочных элементах глушителей	0,22	0,48	0,49	0,52	0,55	0,45	0,40	0,44
(10) Кирпичная крошка в пластинчатых или облицовочных элементах глушителей	0,31	0,50	0,63	0,67	0,65	0,65	0,65	0,58

Key: (1). Coefficient of sound absorption in frequencies. (2). Designation of materials. (3). Average/mean in all frequencies. (4). Slag wool of the mark/brand "150" of Krasnopresnenskiy of the combine of construction materials. GOST 4640-52. Specific weight 150 kg/m^3, by thickness of 100 mm. (5). The same, with a shielding from blowing layer of fiberglass of asim-9 with a thickness of 9 mm, closed by glass cloth. General thickness 100 mm. (6). Fiberglass 25 μ in lamellar or facing silencers. (7). the departure/withdrawals of kapron filament in the lamellar or facing cell/elements of silencers. (8). Construction oakum in the lamellar or facing cell/elements of

silencers. (9). antipyrized cotton in the lamellar or facing cell/elements of silencers. (10). Brick grit in lamellar or facing the cell/element of silencers.

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For imparting to the sound-deadening cell/elements by that necessary forms, and also for the prevention/warning of sound-absorbings material from blowing are applied different protective clothing. Basic requirement for these shells consists in the fact that they must have numerous, evenly arrange/located over the surface of hole for the pass of acoustic waves. In this case, to favorably have the larger possible number of eyelets. the total area of holes with their diameter from 2 to 3 mm must comprise not less than 20o/o entire surface of shell. With an increase in the diameter of holes from 3 to 5 mm, their total area must be not less than 35o/o.

As protective clothing can be used for gas-discharge silencers metallic perforated sheet or metallic fine screen with cells 1.4 x 1.4 mm 0.6-0.7 mm in gauge. With thickness of sheet not more than 1.2 mm in it can be obtained the holes by gap on press by the corresponding set of the punch/male dies with a diameter of 3.0 mm with the space of perforation 4.5-5.0 mm. For more light-gauge sheets the diameter of holes it can be obtained by this method to 2 mm.

Perforated sheets can be applied for all fibrous sound-absorbings material, except friable. Depending on the temperature conditions of gas-discharge silencer, the wire gauze can be applied both of the heat-resistant and made of simple steel.

During application/use for these silencers of fiberglass, mineral wool or slag wool between the perforation plate or the grid and sound-absorbing material must be packed the glass cloth, which prevents filament from blowing their gas flow.

For air-intake silencers, and also for the facing sound-absorbing panels as protective clothing, besides those who were indicated, can be used perforated/punched shells of polyvinyl chloride plastic or vinyl chloride sheet material or from other sheet materials (plywood, fiber so forth).

All the enumerated protective clothing with the observance of the size/dimensions of perforation and mesh are not virtually decreased the coefficient of sound absorption. The thickness of perforated sheet also does not affect the effectiveness of sound absorption.

For the air-intake silencers, working with normal atmospheric conditions, most frequently apply such sound-absorbings material both

the construction oakum, departure/withdrawals of flaxen filament, antipyrized cotton cotton, the departure/withdrawals of kapron filament, etc. Such materials, which have stronger and longer filament, do not require the use of the additional cotton or glass-woven packing and are packed directly under perforated sheet or grid.

For the purpose of the savings of expensive or scarcer sound-absorbings material, their packing in panel or the sound-deadening cell/elements can be produced into two layers.

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The layer, which adjoins the protective clothing, is fulfilled from better-quality material, remaining sound absorber is applied cheaper, for example, slag wool or mineral wool with a thickness of 70-80 mm and skin from the fiberglass with a thickness of 30-20 mm. Can be also proposed other combinations.

This two-layer packing of sound-absorbing material in some cases can give the essential savings of money resources without a reduction/descent in the coefficient of sound absorption or under very insignificant difference and the effect of noise suppression.

The nomenclature of sound-absorbings material can be considerably expanded because of the use of the local fibrous and porous materials, including wastes of industrial or agricultural production.

§5. Diagrams and the constructions of the sound-deadening devices.

1. Reduction/descent in the noise by the sound-absorbing facing.

With the arrangement of testing units in common/general/total hall in the presence in them of closed gas bleeder and on low noise level, is sometimes possible to lower the noise indoors to the maximum permissible values. This can be reached by processing the internal surface of walls and ceiling overlaps by sound-absorbing panels. In this case, a reduction/descent in the noise is achieved because of shortening in the reverberation time, as a result of the active absorption of the acoustic waves, falling/incident to the internal surface of the supressed location.

For this, all the free from glazing surfaces of walls and ceiling overlaps are cover/coated with sound-absorbing panels

(panels). In construction they are similar to the lamellar cell/elements of silencers, used for the intake air-inlet devices whose description is given below. These facing, sound-absorbing panels differ from the lamellar the fact that they are manufactured one-sided with a thickness of 100 mm.

The total surface of the coating of the sound-absorbing facing must comprise not less than 50-60o/o entire internal surface of noiseproofed room. The facing can give overall noise reduction on 5-10 dB and to larger degree in high frequencies. It should be noted that this reduction/descent in the noise composes the very perceptible value which is subjectively absorbed by audition as reduction/descent in the volume respectively to 30-50o/o.

The advisability of the application/use of the sound-absorbing facing is limited to determined by the conditions given in [11].

On the basis of practical data, it is considered that the application/use of the sound-absorbing facing makes sense in the cases, if they make it possible to decrease the reverberation time (minimum to three fourths of its initial value), in locations whose height is it is not more than 3 m.

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In higher locations with the observance of the conditions when the total volume of location must not exceed 300-5000 m^3, or the location is must have the form of the corridor in which one of the linear dimensions of location it must be comparatively great with respect to two to others.

In the majority of cases of practitioner, it confirms these recommendations, and they can serve as base/root when selecting the methods of the smothering of noises at experimental stations. In the locations, which do not satisfy the given conditions, certain reduction/descent in the noise can be reached also because of the setting of the sound-absorbing panels directly of stands, as this is shown in Fig. 28.

In this case the effectiveness of a reduction/descent in the noise will depend on how fully and will be thoroughly shielded by the sound-absorbing panels each stand.

Sometimes for partial protection from noise, can be used the fenced off from common/general/total location soundproofed cabin/compartments of control. Such cabin/compartments will be advisable only in such a case, when tests will be prolonged, and the

stay of the service personnel of stand short-term.

For lowering in the noise level in outer zone in area of the arrangement of the experimental station of the system of gas bleeder, they must have silencers, possible diagrams and constructions of which are examined below.

With the arrangement of testing units in separate boxes, the solution of the problems of noise suppression consists in the equipment of the air-inlet and gas-bleeding channels, which impart box with the surrounding atmosphere by silencers with the necessary level of silencing, and in the provision for the required soundproofing of adjacent with boxes locations. A reduction/descent in the noise in air-inlet and gas-lead channels or air-gas pipes is achieved by placing in them different sound absorbers or acoustic filters, and also in their combination in the form of combined dampers.

2. Silencers with the absorption of noises.

In connection with experimental stations from different methods of silencing of noises greatest application/use find lamellar and

cylindrical sound absorbers or the tubular constructions of the silencers whose diagrams are given in Fig. 33, 35 and 36.

Silencers with lamellar sound absorbers. Such silencers (see Fig. 33) they consist of the sound-absorbing panels (panels), in parallel installed in channel or air duct. The distance between panels is accepted according to acoustic and hydraulic designs and it is usually 200-400 mm (in world/light). The thickness of each such panel must be within limits 180-200 mm, which is dictated by the need for the absorption of low frequencies. The form of air-intake channel does not in effect affect the effectiveness of damping and it is accepted according to design considerations.

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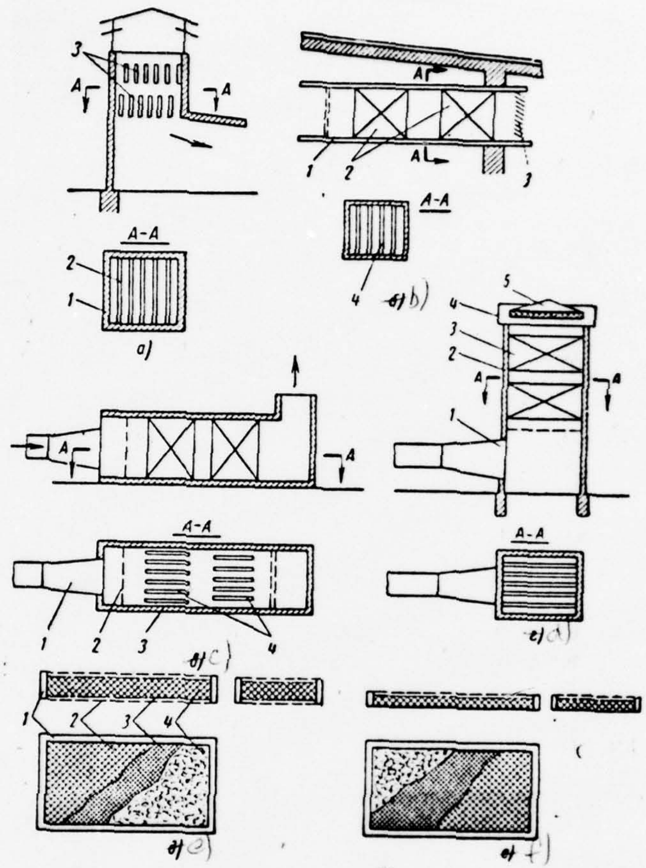

Fig. 33. The diagrams of silencers with the lamellar sound absorbers: a) vertical muffler on the procedure of air; 1 - silo; 2 - lamellar sound absorber; 3 - two sections of lamellar sound absorbers, establish/installed in checkered order; b) horizontal muffler on air-procedure; 1 - tangential channel; 2 - two sections of lamellar sound absorbers; 3 - louvered grate; 4 - lamellar sound absorber; c) horizontal muffler on the gas bleeder: 1 - ejection pipe; 2 -

leveling grate; 3 - tangential channel; 4 - two sections of lamellar sound absorbers; d) vertical muffler on the gas bleeder: 1 - ejection pipe; 2 - silo; 3 - section of lamellar sound absorbers; 4 - shielding canopy; 5 - cap/hood of canopy with the coating of lower plane with the sound-absorbing facing; e) the lamellar sound absorber: 1 - framework/body of panel; 2 - perforated sheet or steel mesh; 3 - protective clothing (glass cloth); 4 - sound-absorbing filler; f) lamellar facing sound absorber (one-sided).

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In particular for lamellar sound absorbers, on the basis of conveniences and the uniformity of the manufacture of panels, the cross section of channel to conveniently have square or rectangular form.

In the zone of the unit of sound absorbers the clear opening of channel or air-gas pipe decreases because of its blanket by the sound-absorbing panels. With the indicated distances between the silencers of this blanket is approximately 50-25o/o of total cross section. The necessary dimensions and the section/cuts of channels are determined by calculations indicated above. The average speed of air intake or air-gas flow in the zone of silencer is accepted

depending on the permissible hydraulic resistance and the life of the sound-absorbing constructions to efflorescence. The practice of the prolonged operation of similar silencers showed that these speeds for the described below constructions and materials can be accepted for air-inlet systems to 25 m/s and gas-bleeding to 50 m/s.

The construction of channel or air-gas pipe can be made from any building materials, which age/hold the temperature conditions of air-gas flow. In the case of applying the metal constructions made of sheet steel, it is necessary to provide for the internal or external sound-proofing facing. In this case to more expedient utilize the internal facing which will appear as the sound-absorbing construction, so also by the sound-proofing protection (see Fig. 36). Structurally this facing must be carried out analogously with the sound-absorbing panels and has thickness 100 mm. Air-intake channels and air-gas pipes can occupy different position relative to building and to be furnished vertically or it is horizontal. Are most common and more convenient vertical silencers as occupying smaller area in territory near experimental station.

Installation and fastening silencers is produced on supporting/reference foundations. holes within walls for the pass of ejection pipes must have elastic stuffing-boxs seal for providing the linear displacements of these tubes during heating. For this purpose

must be used thermoresistant packing/seals of asbestos or fiberglass.

For the protection of silencers and structures from atmospheric residue/settlings the vertically arranged shaft/mines and the tube of air-inlet and gas-bleeding systems, must be shielded by canopies. Some standard diagrams of these canopies are shown in Fig. 34. One of most suitable is canopy (Fig. 34a). It is simple in manufacture, it possesses small hydraulic resistance and it directs well waste gases upward. For an increase in the effectiveness of the smothering of noise, the lower side of cone of protection is cover/coated with sound-absorbing material.

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Silencers with sound-absorbing material encompass frequency band on entire spectrum of the noise engine characteristics. Such silencers more active absorb the noise of the high and medium frequencies whose level is predominating, and therefore they are most general-purpose. In comparison with other silencers by such, for example, as chamber, these silencers possess very insignificant hydraulic resistance. The value of the silencing of the types of silencers in question depends on three basic parameters: from the coefficient of the sound absorption of the used materials; from the relationship/ratio of the perimeter of the section/cut of the unit cell, covered with sound-absorbing material, to the area of this cell and from the length of silencer.

Smothering in decibels 1 linear m. of the length of silencer is determined from the formula of A. I. Belov.

$$\Delta L = k \cdot \alpha \frac{P}{S} \text{ dB}, \qquad (43)$$

where ΔL is smothering 1 lin. m. of the length of silencer in dB;

k - proportionality factor; for the constructions in question it is possible to accept k = 1.10-1.30;

α - the coefficient of the sound absorption of the material, used as sound absorber; the value of this coefficient is accepted according to handbooks; for the most widely used materials of its value, are given in Table 11;

P - the perimeter of the surface of the coatings with sound-absorbing material on the section/cut of the unit cell of silencer in m;

S - the area of the unit cell of silencer, limited by perimeter P and by the untreated surfaces of cell in m^2.

For determining common/general/total from all frequencies smothering, it is possible with sufficient for practical accuracy/precision to use the average coefficient of sound absorption α. If necessary for more precise calculation of the same, it is produced on each octave band separately with the subsequent acoustic summation.

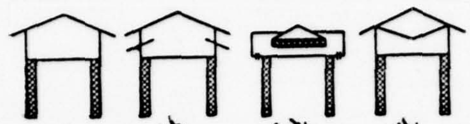

Fig. 34. Diagrams of canopies to vertical silencers; a) tent or conical roofing for air-intake shaft/mines and tubes; b) tent roofing with additional shielding blades; c) plate canopy for gas-bleeding shaft/mines and tubes, on perimeter of shaft/mine shell has holes for run off; d) canopy with director cone for gas-bleeding shaft/mines.

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The overall length of the active part of the silencer, sound-absorbing panels or sound-absorbing facing is defined as quotient of the division of the common/general/total, required level of smothering, into the smothering 1 lin. m., obtained from formula (43).

Silencers with cylindrical sound absorbers. Cylindrical sound absorbers, just as lamellar, are applied for the relatively large cross sections of the air-intake and gas-bleeding channels and shaft/mines, intended for the large flow rates of air or gas-air mixture. An elementary component/link of this type of silencer is the cylinder, manufactured from steel mesh or from perforated/punched

sheet steel and filled by sound-absorbing material. The framework of cylinder is the rod, manufactured from reinforcing rod steel and which concludes according to ends with hooks for a suspension. From end/faces the cylinder is closed by the cap/hoods, manufactured from roofing iron.

For decrease in the hydraulic resistance tc cap/hoods is given conical form.

The general view of cylindrical sound absorber and the diagram of their layout in silencer are shown in Fig. 35.

Wide operating experience showed that the cylindrical sound absorbers more reliable and long work under conditions of vertical they work under conditions of vertical suspension; however, they cannot be operated in hcrizontal position for the device of horizontal silencers. In this case they must be made made of sheet perforated/punched steel with a thickness of 1.1-1.3 mm by both the by possessing larger rigidity, and are filled by the light/lung sound-absorbing filler in the form of glass-portage or mineral wool.

In comparison with lamellar cylindrical sound absorbers as a result of different geometric forms have better relationship/ratio of the perimeter of cell to its area, they require the smaller blanket

of clear opening and smaller consumption of sound-absorbings material. Therefore they are more effective lamellar.

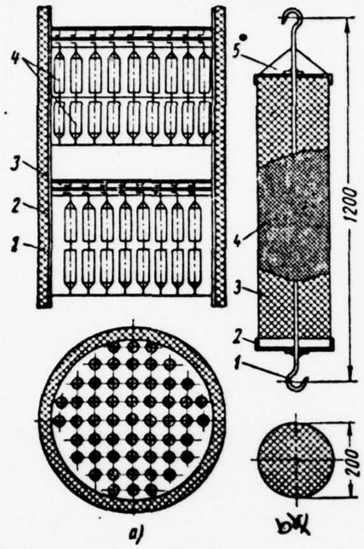

Fig. 35. Diagram of silencer with cylindrical sound absorber: a) arrangement of cylindrical sound absorbers in uptake; 1 - external sound-proofing facing; 2 - metal tube; 3 - beam for suspension of sound absorbers; 4 - section of two series of cylindrical sound absorbers; b) general view of cylindrical sound absorber; 1 - rod with hooks; 2 - cylinder end; 3 - sound-absorbing filler; 4 - perforated sheet or steel mesh; 5 - cap/cover-fairing.

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It is establish/installed that the optimum diameter of cylindrical sound absorber is 200 mm, and the most rational space of their

arrangement in plan/layout along the axes of cylinders is from 250 x 250 to 350 x 350 mm.

The procedure of calculation of smothering by cylindrical sound absorbers is similar lamellar and is produced by the same formula (43).

Tubular silencers find wide application because of simplicity of their construction. Simplest of them those that do not have the internal separating baffle boards. Such silencers, shown in Fig. 36, consist of the metal tube, which is the power framework of entire silencer, and the internal sound-absorbing facing with a thickness of 100 mm. On this diagram these silencers can successfully operate with the diameter of tube to 1 m with useful bore to 0.8 m.

With these size/dimensions the ratio of perimeter to area over the section/cut of tube is approximately 5. With a further increase in the diameter of tube, this sense rapidly is decreased, and therefore the smothering of noise per the unit of length (1 lin. m.) will be insignificant. In this case entire silencer will require a great increase in the length, which will prove to be irrational. Therefore it is necessary to approach obtaining of the higher values of the indicated sense, which will make possible to effectively supress noise at the small dimensions of the active part of the

silencer along the length or height/altitude. This concerns not only tubular, but also examined above silencers with lamellar and cylindrical sound absorbers.

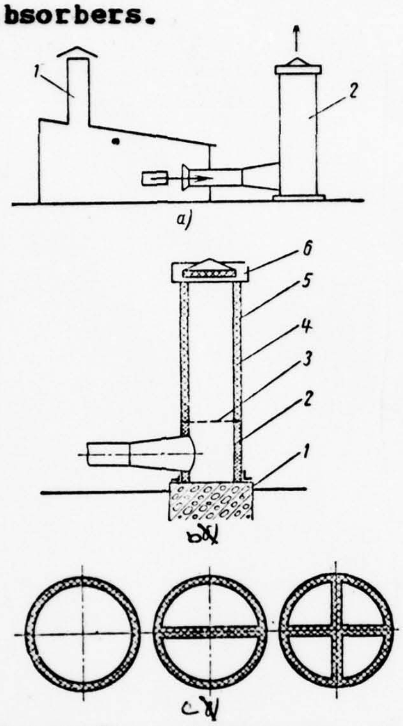

Fig. 36. Diagrams of tubular silencers: a) arrangement of tubular silencers: 1 - suction silencer; 2 - gas-bleeding silencer; b) longitudinal section of tubular gas-bleeding silencer: 1 - foundation; 2 - shielding facing from gas escape jet; 3 - leveling grate; 4 - sound-absorbing facing; 5 - metal tube; 6 - canopy; c) cross section of some types of tubular silencers.

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Of tubular silencers the high values of the ratio of perimeter to area in the section/cut of silencer are achieved by the installation of the separating, baffle boards, as this is shown in Fig. 36 while of lamellar and cylindrical - by a decrease in the distance between their sound-absorbing cell/elements. On the other hand, one should not also to approach an excessive decrease in these distances, since this led to decrease in the clear opening in the zone of silencers, which in final result is led to a considerable increase in the hydraulic resistance.

Manufacture and installation. Sound-absorbing cell/elements of silencers to conveniently manufacture the form of panels, cassettes or cylinders, and then to install them in channels or tubes. With several sections of silencer lamellar and cylindrical sound absorbers one should establish in checkered order, i.e., panels or the cylinders of one series must be moved with respect to another series. This installation gives a considerable increase in the effectiveness of noise suppression.

The sound-deadening devices for air-intake channels work under conditions of the temperature of the surrounding atmospheric air. Therefore for them, and also from the viewpoint of the protection of engine from blockage, most adequate/approaching will be sound-absorbings material of organic origin, such as construction

oakum, purified from boon and dust, combings and the departure/withdrawals of flaxen and cotton fiber or the departure/withdrawals of kapron filament. For air-intake silencers the framework/bodies of panels can be made from the tree, impregnated with flameproof compositions. The size/dimensions of the sound-absorbing panels should be accepted on the basis of the dimension of channel; however, for convenience of their installation, one ought not to make along the length more than 1.5-2 m, but the width more than 0.8-1.0 m.

In uptakes or shaft/mines, cylindrical sound absorbers are hung to metallic beams for hooks, and they are linked from below between themselves by the wire whose ends are fastened to lateral canal surface. Tubular silencers to conveniently manufacture in the form of cassettes or in the form of separate component/links together with tube. Fastening their separate component/links between themselves is produced with the aid of flange joints on bolts.

In the gas-bleeding silencers sound-absorbings material and their parts must be flameproof, capable of working under conditions of high temperature conditions. Therefore all the constructions of the sound-absorbing cell/elements of these silencers are manufactured from metal. Of sound-absorbings material for this purpose, is most appropriate the fiberglass the diameter of filaments not more than

20-25 μ, mineral wool, brick or pumice grit. The first of two materials and to them similar require the application/use of additional protective clothing, i.e., glass cloth. Temperature conditions for these materials must not be above 300-350°C, otherwise can occur their fusing. The temperature conditions of waste gases for brick and pumice grit is limited by the thermal strength of metal constructions. For providing the prolonged operation of such silencers, it should be accepted its above 400-450°C.

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For this grit one should use mesh made of heat-resistant steel. Grit with this mesh does not require additional protective clothing.

For testing units with radiation level of noise 120-125 dB it is higher on conduit/manifolds and ejection pipes, which connect installation with silencer, one should provide for the sound-proofing facing. It to conveniently fulfill outside tube in the form of jacket from fine/thin steel plate with the filling of interval/gap (it is not less than 60-80 mm) by sand or packing of any other thermal insulation material.

3. Chamber silencers.

Jet/reactive silencers or the acoustic filters, more frequent called chamber silencers, they consist of the consecutive expansion chambers, connected between themselves the conduit/manifold for the pass of waste gases. The schematic diagrams of some types of chamber silencers are given in Fig. 37.

In comparison with others, these silencers with expansion chambers create the greatest counterpressure whose value for single-chamber silencers is found within the virtually permissible limits. As a rule, single-chamber silencers are applied under the condition of the need for the smothering of small range of frequencies mainly within limits 100-600 Hz. For the absorption of other higher noise frequencies, the silencer must consist of several different in volume chambers or combine the low-frequency and high-frequency diagrams of chamber silencers. This development of silencer unavoidably is led to a sharp increase in it hydraulic from resistances and, of course, to loss of power of tested engine, coming out beyond limits of accuracy of measurements. For decrease in the resistance, can be applied the forced ejectors and exhaust fans which, however, raise in price and complicate the operation of testing units. Therefore chamber silencers, being by its construction

simple in manufacture and operation, they can widely be applied when certain power loss is permissible.

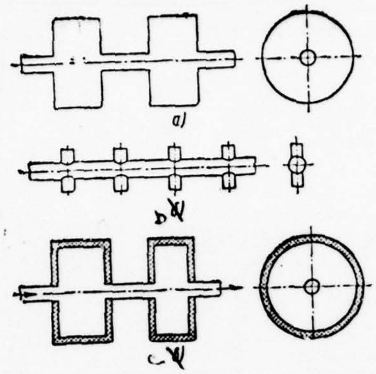

Fig. 37. Schematic diagrams of chamber silencers: a) low-frequency; b) high-frequency; c) silencer with noise-absorbing coating and with chambers of different length.

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Virtually with the common dimensions of chamber silencers, power loss without the forced removal/taking of hydraulic resistance comprises for single-chamber silencers to 1o/o, and for 2-3 chamber one-type or combined to 1.5-2o/o. Such silencers are applied mainly during the closed gas-bleeding systems for testing or the operation of piston engines.

Still finished at present the procedure of acoustic calculation of chamber silencers, it thus far is still complex and not always

does coincide with data, obtained in nature. Approximate computations can be carried out by the given below theoretical formula of noise suppression in one chamber

$$L_{\kappa} = 10\lg\left[1 + \frac{1}{4}\left(m - \frac{1}{m}\right)^2 \sin^2 kl\right] \text{ dB} \quad (44)$$

where L_{κ} is noise suppression during expansion in one chamber in dB;

m - expansion ratio (ratio of the area of the chamber of expansion to the area of intake pipe);

k - the frequency factor of the supressed sound and speed of sound at the given temperature of gases $k = 2\pi f/c$, where f - the frequency of the supressed sound, determined by formulas (38) and (39);

c - the speed of sound in this medium, determined by formula (36);

l is length of expansion chamber.

This theoretical formula completely satisfactorily will agree with data, obtained in nature, on the condition that the diameter of expansion chamber will be equal to 0.8 acoustic wavelengths or is less than this value. According to practical data, is recommended the degree of expansion the having of within limits of $m \approx 20$-30. The

introduction inside the chamber of facing from sound-absorbing material leads to an increase in the absorption of the noise of high frequencies.

4. Sound-proofing constructions.

To avoid noise transmission from boxes and locations of testing units into the cabin/compartments of control and other adjacent with them locations, one should produce the soundproofing of these locations. Measures for soundproofing are reduced to isolation/insulation of walls and partition/baffles from noise transmission; to the device of the soundproofed gates, doors and windows; the soundproofing of channels, conduit/manifolds and other communications, which connect boxes and adjacent with them locations.

The required value of the sound-proofing ability is determined by the difference in the levels of noise in box and in the required noise level of adjacent location. In this case, as a rule, the sound-proofing ability of enclosure/protection must be somewhat higher than this difference.

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According to the effective norms (see N 101-54, publication 1958), the average sound-proofing ability of anechoic walls, partition/baffles and other enclosing panels is determined from two following formulas:

with weight 1 m^2 of partition/baffle to 200 kg/m^2

$$U = 13{,}5 \lg G + 13 \text{ dB}; \qquad (45)$$

with the weight of the m^2 of the partition/baffle above 200 kg/m^2

$$U = 23 \lg G - 9 \text{ dB}, \qquad (46)$$

where U is the sound-proofing ability of partition/baffle a dB;

G - weight 1 m^2 of partition/baffle in kg.

For common walls and partition/baffles, their soundproofing is determined by the weight with increase in which the soundproofing of enclosure/protections grow/rises.

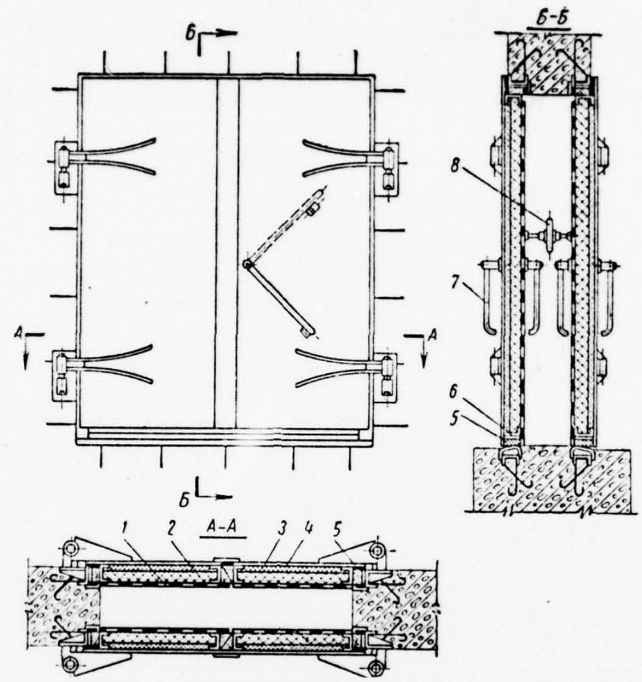

Fig. 38. General view of construction of soundproofed gates: 1 - perforated/punched steel plate or wire gauze; 2 - slag cotton or fiberglass; 3 - layers of Ruberoid; 4 - steel plate; 5 - wooden beam with rubber gasket on entire perimeter of aperture; 6 - metal frame winch; 7 - knob/stick lever with wedge-shaped lock; 8 - tie piece cover for clamp of widths winch with spiral handwheel.

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If necessary of applying their more light/lung in weight constructions one should make two-layered with the air gap. In this case the soundproofing will be above than single-layer construction with the same weight.

Those who were soundproofed gate, doors and windows are arranged according to this same principle. Besides by maximally folding with dense locking. The latter is achieved by the application/use of elastic packing/seals on the perimeter of locking. For providing the dense clamp of gates or doors to their sockets they equip with wedge-shaped lever/crank locks. Fig. 38, depicts the general view of the soundproofed gates, door also they are fulfilled analogously with the given construction. Such of winch and doors should be applied for the testing units, arrange/located in the boxes where the noise level exceeds 110-120 dB. For an increase in the soundproofing of similar gates and doors, the internal surfaces of their fabrics cover/coat with the sound-absorbing facing. The soundproofed observation windows must have double glazing with the air gap of thickness not less than 100 mm.

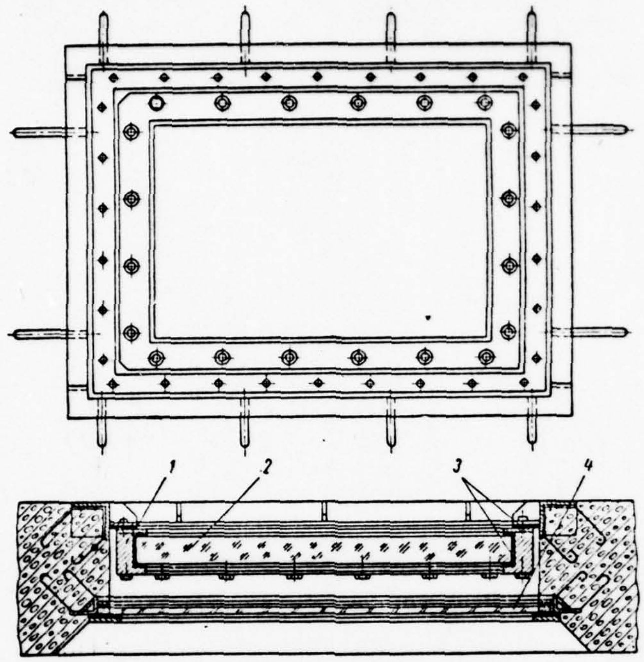

Fig. 39. General view of construction of soundproofed window between box and cabin/compartment of control: 1 - ring- frame; 2 - silicate or organic armor-piercing glass; 3 - packing/seal rubber; 4 - glass more front/leading (to box).

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On by the considerations of soundproofing and the technicians of safety for operator's protection from fragments during the possible destruction of window from the impact/shock of the detached rapidly rotating parts of engine glazing window must be armor-piercing of the

silicate or of organic glass not less than 40-60 mm in thickness. Sometimes this thickness increases double and more. Such glasses are manufactured with the Soviet industry of sufficiently large size/dimensions, and they can successfully be applied for the indicated target/purposes. Glasses are laid into the rings of frame with elastic rubber or plastic packing/seal and with the aid of loops and bolts are fastened into the seats of the window aperture, edged by reinforced concrete and metallic frames. As an example Fig. 39, gives the construction of the soundproofed window. If necessary for the prevention/warning of the codensate between glasses for interval/gap, is establish/installed or is screwed in the socket with moisture absorber, for example, by silica gel.

Large of value for providing the necessary soundproofing has also the careful framing of holes, slots, channels and conduit/manifolds, passing through the box and adjacent with it locations. With the necessity for channels, are establish/installed lamellar or facing sound absorbers, and if is represented possibility, in them are furnished passages. Conduit/manifolds must be packed in the collector/receptacle, charged after the installation of tubes by sand.

Chapter IX.

LABORATORIES OF ENGINES AND GAS-DYNAMIC LABORATORIES.

§1. Purpose and the composition of laboratories.

The laboratories of engines and gas-dynamic laboratories are the component part of the experimental base of design bureaus or scientific research organizations, working in the region of engine construction. These laboratories are intended for the different experimental and research works, which consist in testing of theoretical developments and research on processes, which occur in engine and its aggregate/units. In them is carried out also the functional test of the constructions of separate units and engine as a whole.

In them are carried out the works, connected with an increase of the engine life, the selection of new materials, functional check of its under different climatic conditions, the tests of starters, by

the selection of new fuel/propellants and oils of other testings.

In connection with piston internal combustion engines such laboratories more frequently call the laboratories of engines, and for gas turbines - gas-dynamic. Both for the first and for the second laboratories equipment their will somewhat differ, although in the designation of their department/separations and the direction of works at them has much that is in common.

The composition of laboratory - a quantity of installations and its equipment - will depend on airfoil/profile, character, directivity and the scale of the works of design bureau or other organizations, which are occupied by research works on engines.

When selecting the type of testing units and basic equipment, one should consider the possibility of the promising development of the separate constructions of engines. Therefore frequently appears the need for the subsequent modernization and reconstruction of these installations.

Table 12 gives the exemplary/approximate composition of the laboratory of engines and gas-dynamic laboratory with the indication of their thematic division and set of basic testing units and stands.

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Table 12. Exemplary/approximate composition of the laboratory of engines and gas-dynamic laboratory.

Наименование отделений и групп (2)	(1) Состав основных испытательных установок и вспомогательных служб	
	(3) Поршневые двигатели — лаборатория двигателей	(4) Газовые турбины — газодинамическая лаборатория
(5) I. Производственные отделения или участки:		
. Рабочих процессов горения (6)	Одноцилиндровые установки (7)	Установки испытания камер сгорания (8)
2. Лопаточных машин (9)	Для двигателей, имеющих агрегаты наддува, установки для испытания нагнетателей (10)	Установки для испытания компрессоров, турбин, продувки лопаток, решеток, сопел (11)
3. Топливных систем (12)	Стенды для испытания карбюраторов, жиклеров, топливоподкачивающих помп, фильтров, двигателей непосредственного впрыска топливных насосов, регуляторов и форсунок (13)	Стенды для испытания командно-топливных агрегатов, насосов, форсунок, регуляторов. (14)
4. Топлив и масел (15)	Одноцилиндровые установки. Установки для оценки детонационных свойств топлив (16)	Установка испытания камер сгорания (8)
	Аппаратура и приборы для проверки и анализа физико-химических свойств топлива, масел и консистентных смазок (17)	
5. Систем смазки (18)	Стенды для испытания маслопомп, регуляторов давления, фильтров (19)	
6. Системы зажигания и электрооборудования (20)	Стенды для испытания электрогенераторов, свечей зажигания и прочего электрооборудования (21)	
7. Теплообмена и охлаждения (22)	Стенды для испытания водяных насосов, радиаторов и подогревателей (23)	Стенды для испытания теплообменных аппаратов (24)
8. Передач, приводов и пусковых устройств (25)	Стенды для испытания редукторов, коробок передач или гидропередач и стартеров (26)	
9. Автаматики и регулирования (27)	Стенды для испытания агрегатов систем автоматики, регулирования и блокировки (28)	
10. Испытания двигателей (29)	Установки для испытания двигателей в нормальных и в искусственных особо тяжелых климатических условиях (30)	
(31) II. Вспомогательные отделения и службы:		
1. Препараторская (32)	Для подготовки отдельных агрегатов и двигателей в целом к испытаниям (33)	
2. Приборная (34)	Для тарировки, подготовки и хранения контрольно-измерительных приборов (35)	
(36) 3. Мастерская механика	Изготовление мелкой оснастки и оборудования для установок и стендов (37)	
(38) 4. Электромашинный зал	Для размещения преобразовательных и электрораспределительных устройств (39)	
5. Прочие службы (40)	Аккумуляторная, маслокомната, кладовые и прочие службы (41)	
6. Помещения технического и обслуживающего персонала (42).	—	—
(43) 7. Бытовые помещения	—	—

Key: (1). Composition of basic testing units and auxiliary services. (2). Designation of department/separations and groups. (3). Piston engines is a laboratory of engines. (4). Gas turbines is a gas-dynamic laboratory. (5). Production department/separations or the sections: (6). Operating conditions of burning. (7). Single-cylinder installations. (8). Settings up of testing combustion chambers. (9). Rotodynamic machines. (10). For the engines, which have the aggregate/units of pressurization/supercharging, stand of superchargers. (11). Stands of compressors, turbines, blasting of blades, grates, it puffed. (12). Fuel systems. (13). Test benches of carburetors, discharging jets, of the booster pumps, filters, fuel injection engines of fuel pumps, regulators and injectors. (14). Test benches of automatic fuel control aggregate/units, pumps, injectors, regulators. (15). Fuel/propellants and oils. (16). Single-cylinder settings up. Settings up to evaluate the knock properties of fuel/propellants. (17). Equipment and instruments for testing and analysis of the physicochemical properties of fuel/propellant, oils and grease. (18). Lubrication systems. (19). Test benches of oil pumps, pressure regulators, filters. (20). Ignition systems and electrical equipment. (21). Test benches of electric generators, sparkplugs and other electrical equipment. (22). Heat exchange and coolings. (23). Test benches of water pumps, radiators and preheaters. (24). Test benches of heat exchangers. (25). Transmissions, drives and starters. (26). Test benches of the reducers of gearboxes or hydro-transmissions and starters. (27). Automatics and controls. (28). Stands for tests of the

aggregate/units of the systems of automation, control and blocking. (29). Engine tests. (30). *propulsion test facility* in normal and under artificial extra-heavy climatic conditions. (31). Auxiliary department/separations and services. (32). Preparatory. (33). For training/preparation of separate aggregate/units and engines as a whole for tests. (34). Instrument. (35). For calibration, training/preparation and storage of control gage instruments. (36). Shop mechanics. (37). Manufacture of small equipment and equipment for installations and stands. (38). Dynamoelectric hall. (39). For the arrangement/permutation of transformative and electrical distribution devices. (40). Other services. (41). Battery room, oil room, storeroom and other services. (42). Locations of the technical and service personnel. (43). Everyday locations.

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§2. Tests of engine accessories.

1. Stands of compressors.

These settings up are intended for the study of testing and performance testing and calibration of the axial-flow or centrifugal compressors of gas turbines. Since the full-scale compressors for some engines require very large powers for their drive, at these settings up can test the models of such compressors or their separate step/stages. Similar tests make it possible to considerably decrease the driving power of setting up. The schematic diagram of stand of compressor is given in Fig. 40. The basic cell/element of setting up, which determines its character, is the type of drive. The main requirements which are presented to drive, consist in the provision for a broad band of the control of the rate of the rotation of compressor with the possibility of power measurement. Fig. 41, shows the used types and the diagrams of drives. The most convenient and reliable drive are the special electric motors of a series ATM with the high-frequency control of the speed, obtaing supply from the group of converters in the form of motor generators or the mercury-arc rectifiers. These high-speed electric motors in the indicated power-supply system permit implemention of rpm control over a wide range from 0 to 15000 r/min. In the majority of cases, this makes it possible tc manage without the raising multipliers during direct drive from the shaft of electric motor to the shaft of compressor. If necessary for power measurement, consumed by compressor, the electric servomotor can be installed on bob platform whose possible diagrams are examined above. To shortcomings in the

indicated type of drive, one should relate the high cost/value of converters and the need for the isolation/liberation of considerable area for their arrangement/permutation.

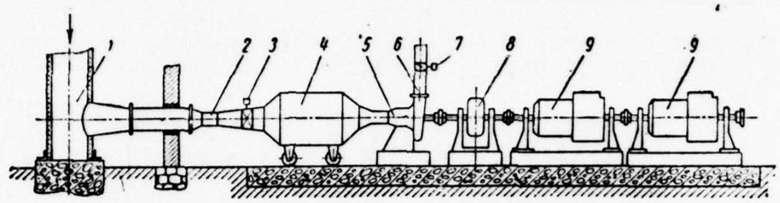

Fig. 40. Schematic diagram of stand of compressor of gas turbine: 1 - shaft/mine of suction with noise absorption; 2 - measured collector/receptacle; 3 - throttle/choke at entry; 4 - receiver; 5 - tested compressor; 6 - exhaust collector/receptacle; 7 - throttle/choke at output/yield; 8 - multiplier during bob suspension; 9 - bob machine of direct current.

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Sometimes as the drive of tested compressor, can be used gas turbine or another engine. In the first case it will be necessary to establish/install the combustion chamber for feeding of which will be necessary the compressed air, supplied from compressor or from auxiliary gas turbine with air bleed. From drives of this type, the drive from gas turbine engine will be in the majority of cases simpler and more convenient than drive from gas turbine. The selection of the latter can be dictated by the need of obtaining heavy-duty drive which cannot be obtained from engine. To shortcomings in these drives, one should relate the presence of limitations in obtaining of the required power at the different rate of the rotation of drive shaft.

The remaining types of drives, possible to use, require the application/use of relatively complex by construction multipliers. The control of speed must be produced with the aid of converters in the form of motor generators or the mercury-arc rectifiers for the machines of direct current or by the means of hydraulic coupling during the use of common electric motors of alternating current.

For purposes of safety of work and noiseproofing of other locations laboratory stands of compressors one should furnish in the isolated/insulated boxes from partition in them isolated/insulated cabin/compartment of control.

During testing of high-speed compressors with the speed of the rotation of ball of more than 10000 r/min, power in the drive of more than 1000-1500 ℓ. s., the air ducts or the shaft/mines of sampling and ejection of air are subject to equipment by the sound-deadening devices. Electric drives of the type ATM with power of 1800 kW and above and other powerful electric motors, and also the transformative motor generators require the device of basement in area of their arrangement for the arrangement/permutation of the ventilation installations of cooling.

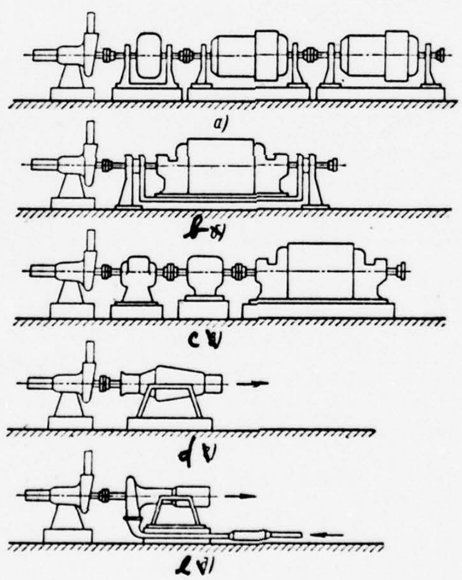

Fig. 41. Diagrams of drives of compressor at testing units: a) two machines of direct current with multiplier of speed, establish/installed on balance suspension or platform; b)

high-frequency electric motor of series ATM on bob platform, c) synchronous electric motor, hydraulic coupling and multiplier; d) gas turbine; e) gas turbine with feeding from bench combustion chamber and with supply of compressed air from industrial compressor.

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For the purpose of shortening of conductive mains and decrease in the losses of electric power, the dynamoelectric hall of converters or the location of the mercury-arc rectifiers one should furnish as far as possible nearer to the units of testing the compressors and other large adjustable drives.

Control panel is equipped by starting systems, control and controls of unit, and also the monitoring-measuring equipment, which allow depending on the velocity of rotation and power input to determine pressures and temperatures of air according to the channel of compressor, but productivity - according to consumption and pressure.

2. Stands of turbines.

These units are intended for full-scale tests and performance testing and calibration of the gas turbines of the improved or new constructions. Here the products of burning into turbine enter from bench combustion chamber, where is fed the compressed air from compressor station. After the expansion of combustion products in turbine, waste gases through exhaust nozzle head directly or through recuperators for the gas-bleeding system of unit. The developed with turbine power is absorbed by braking device which is equipped with the measuring system of the torsional moment.

The schematic diagram of setting is given in Fig. 42. Since the shaft of turbine is connected directly with the shaft of braking device, eliminating the reduction of the speed, brake itself must be high-speed and it must be designed to the appropriate maximum rpm of turbine. Therefore the most adequate/approaching and the only possible the application/use types of brakes will be the high-speed induction or hydraulic brakes. The characteristic features of these brakes are presented above, in chapter II.

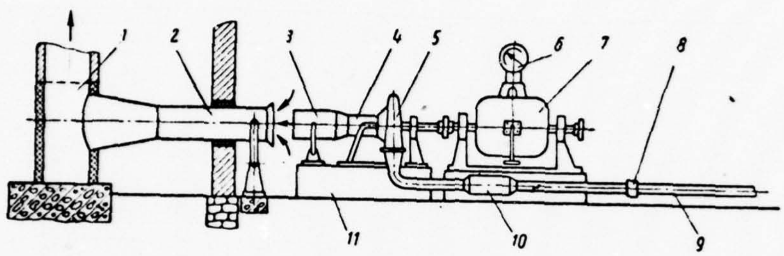

Fig. 42. Schematic diagram stand gas turbines: 1 - gas outlet shaft/mine with noise suppression; 2 - ejection pipe; 3 - gas-discharge tube; 4 - tested turbine; 5 - preheater (combustion chamber) of high temperatures; 6 - dynamometer (weight head); 7 - induction brake; 8 - metering nozzle; 9 - air duct from compressor; 10 - preheater (combustion chamber) of mean temperatures; 11 - stand-support.

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Stands of turbines, just as the preceding/previous units, for the purpose of the provision for safe work and soundproofing of other locations of laboratory must be furnished in insulated boxes with the fenced off cabin/compartment of control. Since the noise level of

unit approaches a noise level, isolated as by full-scale gas turbine, the gas-bleeding system of this unit is also equipped by the sound-deadening devices.

The control panel of unit is equipped with propellant utilization systems, remote ignition of mixture in the combustion chamber, control of air-gas pipes and with the monitoring-measuring equipment, which make it possible to determine the flow rate of air, the speed of the shaft of turbine, the torsional moment, the consumption of fuel/propellant, temperature and the air pressure and gas according to entire channel of unit and turbines.

3. Stands of combustion chambers.

At these units can be produced the wide circle of different works, connected with investigation, finishing and experimental developments in the field of the adjustment of operating conditions of burning. At these units is produced the selection and testing the new types of fuel/propellants, injectors, deflectors and different constructions of combustion chambers as a whole. Work of compressor is here usually imitated by supply to the unit of the compressed air from compressor station in the necessary quantity at the pressure,

which ensures its flow rate for the complete combustion of fuel/propellant in the tested combustion chamber.

This unit, shown in Fig. 43, consists of the supplying air duct with blocking and regulating organ/controls of remote control, stand from subject chamber of combustion, fuel system with the high-pressure pump and gas-bleeding system.

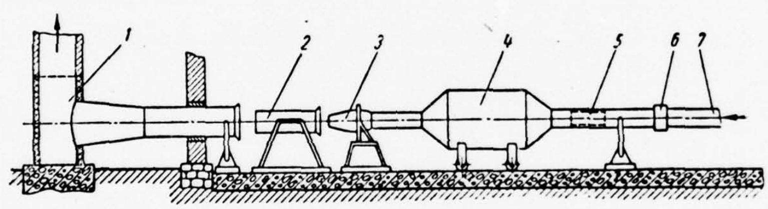

Fig. 43. Schematic diagram of stand of combustion chambers: 1 - gas-bleeding shaft/mine with noiseproofing; 2 - tube-adapter; 3 - tested combustion chamber; 4 - receiver; 5 - air preheater; 6 - metering nozzle; 7 - air duct from compressor station.

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Depending on designation/purpose and character of testing, the combustion chamber can be both by bench construction with its appropriate equipment for conducting of the necessary investigations

and experimental design, replaced on stand as needed. According to the presented considerations stand of combustion chambers must be furnished in separate box with the isolated/insulated cabin/compartment of control. Under the condition of successive work in one box, can be arrange/located 2-3 units in question. In this case works on training/preparation for testing can be produced simultaneously at several units. This fact although decreases possibilities and the maneuverability of installations however it gives the considerable savings of production area and somewhat decreases industrial and technological communications.

This position with the possibility of the arrangement in one box of several test benches can be common also for all the units examined earlier than under the condition of conducting at them of successive tests.

4

The channel of such installations is equipped by the sound-deadening devices. With the arrangement in the box of several installations and their successive work, the gas-bleeding shaft/mine for these installations can be common/general/total. In this case the branch connections of the gas-bleeding systems of each unit must have shutter/valves which with the idleness of any unit are closed.

The control of these installations by analogously

preceding/previous is realize/accomplished from the control panel, equipped with remote starting systems, control and feed controls of air, fuel/propellant, water and oils. Their monitoring-measuring equipment must determine the flow rate of air, consumption and the pressure of fuel/propellant, temperature and pressure according to entire channel of combustion chamber.

4. Single-cylinder and block units.

Adjustment of the thermal processes, which occur in the cylinders of piston engine, research on injection operations of fuel/propellant and carburetion, cooling, lubrication and other questions, connected with improvement and creation of the new constructions of engines, can be produced not on the full-scale engine of experimental design, but at the model, so-called single-cylinder or block unit. The single-cylinder unit whose general view is given in Fig. 44, is single-cylinder engine, which consists of general-purpose bench or special crankcase with the crankshaft, to which is establish/installed experimental cylinder with connecting rod and piston group of the engine being investigated. Crankcase is equipped with assemblies and the systems, which ensure distribution and fuel feed, ignition, lubrications and engine coolings.

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Thus, in the majority of cases cylinder, connecting rod and piston group, and sometimes also the crankshaft are the experimental cell/elements of future engine; therefore they will be the interchangeable, changeable assemblies. Crankcase with its systems and assemblies is, as a rule, by bench, stationary mechanism.

Single-cylinder unit, besides specific tests, makes it possible to produce the finishing of the new constructions of the combustion chambers of cylinder, pistons, rings of the wrist pins and other parts, and also testing new materials to wear resistance, resource and other investigations. Thus, single-cylinder unit makes it possible to considerably reduce the spent resources and time for finishing and testing of the new constructions of the created engines.

Single-cylinder units can be both for the engines of water and air cooling. As braking device in them, is utilized the bob machine of direct current, induction or hydraulic brakes. Everything these of brake must have a measuring system of the torsional moment. Bob machine is the most convenient form of brake, since it can work not

only in generator, but also in motoring and therefore it can be used for starting/launching, warming up and cold run-testing of engine. However, it should be noted that the possibilities of its application/use are limited by the maximum speed of rotation, which is approximately 4000-5000 r/min depending on the type of electric motor. If necessary of applying other types of brakes, the unit must be additionally equipped with starting/launching electric motor.

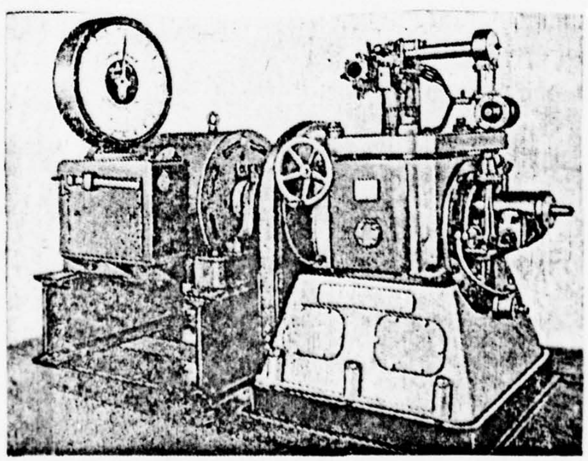

Fig. 44. General view of single-cylinder unit. Braking device is a

bob machine of direct current.

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Since testing single-cylinder engine usually is carried out with the small gas-bleeding branch connection, without gas-discharge collector/receptacle, noise level in work of this engine, even low power, reaches large values and is approximately 110-120 dB and more. Therefore unit must be equipped with the resources of noise suppression. Propulsion test facility of air cooling is equipped by ventilation system by air, that consists of the air extractor, supplying and discharge air duct. The air flow rate for cooling of tested block or single cylinder can be determined by formula (3).

The discharge air duct it is expedient to connect with the gas-bleeding system.

The power-supply systems, control and heat-control/check will be similar with the settings up of testing full-scale engines. For the purpose noiseproofing of single-cylinder units one should place in separate boxes with the fenced off cabin/compartment of control.

Block units differ from the single-cylinder the fact that instead of one cylinder to the appropriate crankcase is

establish/installed the block, which consists of the group of cylinders from the tested engine, which has two or larger number of blocks.

5. Stands of the pumps of engines.

Are this involved stands and stands water, oil and fuel pumps. The designation/purpose of these stands is a functional test and performance testing and calibration on productivity and pressure depending on the speed of pump. As drive is most convenient utilized an electric motor of direct current with the control of speed. With the necessity between the electric motor and the pump, is introduced the multiplier, which raises to necessary speed the revolutions of the leading pump spindle. The schematic diagrams of test benches of pumps have much that is in common. The basic cell/elements of each testing unit are: service tank with the system of preheating and coolings of working fluid, strictly stand for a tested pump with the adjustable drive, common weight or high-speed/velocity type flow meter, the drainage system of the descent of working fluid with its replacement and providing for fire safety, control panel with monitoring-measuring equipment. Besides the pump capacity, on stand are produced the measurements of the speed, temperatures and

pressures before and after pump, and also the temperature of working fluid in service tank.

Depending on the type of the drive, its power and presence of the multiplier of stand of pumps, is produced the noise whose level can be within limits 90-110 dB predominantly at high and medium frequencies.

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Therefore similar units one should place in the isolated/insulated from other services and the installations locations. In this case, in one location, can be arrange/located several test benches of different pumps or engine accessories. In such cases the internal surface of this location one should cover by sound-absorbing panels that it will make it possible to lower noise and to considerably improve working conditions. Structural solutions and the recommendations of this facing are given in chapter VIII.

Panel of control of installations with monitoring-measuring equipment to conveniently dispose of row/series with stands.

Electric motors, whole electrical equipment, power and illuminating guide and electric fittings of stands of fuel pumps must

be explosion-proof. Therefore stands of fuel pumps must be furnished in separate location together with another stands of entire other fuel equipment or in independent location. Application/use as drive for testing of fuel equipment common, dangerously explosive electric motors is allow/assumed only in such a case, when they will be establish/installed indoor, isolate/insulated by anechoic wall from the location of pumping station with the passage of shafting through the intermediate wall with the aid of special gas-impermeable stuffing-boxs seal.

Servicing service tank with fuel/propellant and the drain of the contaminated fuel/propellant is recommended to produce with the centralized way, on the conduit/manifolds, which go from basic or intermediate fuel reservoir, arrange/located outside the building of laboratory.

6. Other testing units and stands.

Besides installations examined above, the nomenclature of the remaining test benches of the laboratories of engines either gas-dynamic laboratories or experimental stations of experimental production can be sufficiently vast. Their need will be determined by

designation/purpose, airfoil/profile and the scale of works of shops, stations and laboratories. Among such installations and stands, one should note:

1. Test benches of the fuel equipment: testing injectors for angle and quality of the atomization of fuel/propellant and productivity; the carburetors mixture holding collector/receptacles, fuel pump regulators, unit for determining the octane number and other propellant properties.

2. Units in the form of airflow laboratories for blasting of blades, cell/elements of grates, branch connections and other parts of gas turbines and their compressors.

3. Units for investigation of heat transfer and testing heat exchangers.

4. Test benches of electric starters, electric generators, relay and other electrical equipment.

5. Stands for adjustment and testing of different mounted mechanisms and assemblies of systems of automation and control of engines.

With the exception of fuel installations for determining the knock properties of the fuel/propellants which are produced by Soviet industry, whole other is optional equipment. Therefore their construction, manufacture and adjustment must be produced on the spot taking into account the specific special feature/peculiarities of separate assemblies, assemblies and mechanisms, which require the tests of concrete/specific/actual engines.

When selecting equipment and the determination of the schematic diagrams of the fuel feed, oil, electric power, air and other forms of power engineering, it is necessary to accept the basic condition/positions, presented above for experimental stations.

During the arrangement/permutation of any kind of testing units and stands for the laboratories in question one should observe requirements with respect to the provision for fire safety, safety engineering and with respect to the limitation of noise in production.

The final stage of experimental or research works of laboratory is conducting the complex tests of the improved or new construction of engine. Besides final official tests, here also can be carried out special works, connected with performance testing and calibration of heat balance, determination of the friction horsepower, efficiency,

determination of resource/lifetime and optimum engine power ratings and others.

For such works in the composition of laboratory, are provided for full-scale units. A quantity of such installations is determined by scale and the character of production and by concrete/specific/actual special feature/peculiarities of the type of engine. The selection of type and equipment of installations, schematic diagrams of feeding one should produce in accordance with the given above reccmmendations for experimental stations. This is related also to the determination of area, the arrangement/permutation, the noise suppression and other questions.

§3. Engine testing under special climatic conditions.

Sometimes for some types of engines, appears the need for testing their efficiency under conditions of the reduced or elevated temperatures and high humidity. This is connected with the operation of the engines, designated to work in different geographic latitudes, sometimes in the presence extra-heavy climatic conditions. The basic types of such tests, by which can undergo the engine in complex combination or only by certain of them, they will be:

1. Testing the starting/launching of engine and starters under conditions of the reduced temperature, for example to -40°C.

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2. Determination of performing characteristics and reliability of the operation of engine in its continuous operation under conditions of the reduced temperatures.

3. The same tests under conditions of elevated temperatures, for example to +60°C.

4. Functional check of engine and its separate assemblies under conditions of those who were increased humidities and temperatures or strong dust content of air and other severe conditions.

The enumerated tests make it possible not only to test and to eliminate defects of the operation of engine as a whole and of its separate assemblies, but also they make it possible to reveal/detect/expose the life of paint and varnish coats, packing/seals, used in engines.

For providing conducting similar tests, usually they resort to creation on the stand of artificial, special conditions. In this case the engine being investigated together with braking device is placed in the special box in which is created the required temperature. Control of this test unit is produced remotely.

Fig. 45, depicts the schematic diagram of box for engine tests under conditions of minus temperatures. This unit is intended for testing of starting/launching and conducting endurance tests of gas turbines under conditions of the reduced temperatures - to -40°C. Stand with engine and braking device is placed in separate box 1, but control panel in the isolated/insulated from box cabin/compartment. Cooling installation with air coolers and auxiliary equipment is placed in the engine house, arrange/located near from box. For decrease in the heat losses during cooling of box internal surface its, door and other apertures have a thermal insulation. The gas-discharge nozzle of turbine 2 and the receiving branch connection of ejector have a jacket with the partition tube, imparted with atmospheric air. This is necessary for providing the inflow of the ejected air and decrease in the thermal cycling in box. The remaining part of ejection pipe, which passes on box and which is imparted with air-inlet tube 3, also has a thermal insulation. Box with cooling installation has two cooling systems of air. One System, on the left side of the given diagram, is intended for cooling of box by the air,

which circulates through air cooler 15 with the aid of fan 16. Cooling air occurs because of the evaporation of ammonia in the air cooler into which it enters from cooler. The latter consists of compressor 12, condenser/capacitor 11 and auxiliary equipment. Another system, arrange/located in the diagram to the right, is intended for the supply of the cooled air into box to the feeding of engine in its continuous operation under conditions low-temperature. It also consists of cooling installation, but higher productivity. Cooling air is produced in air cooler in two step/stages.

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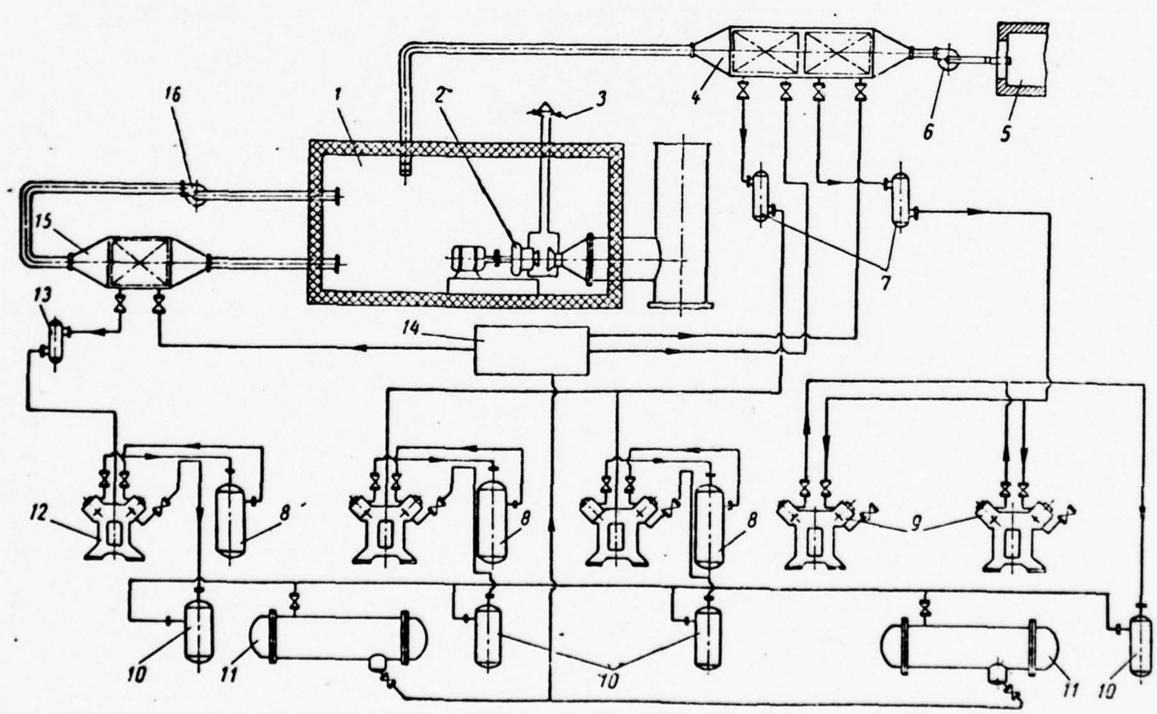

Fig. 45. Caption next page.

Fig. 45. Schematic diagram of propulsion test facility under conditions low-temperature: 1 - box of engine testing at temperature to -40°C; 2 - tested gas turbine; 3 - air-inlet tube of ejected air from atmosphere; 4 - two-stage coolant of air for feeding of engine; 5 - air-inlet shaft/mine; 6 - fan high-pressure; 7 - dehydrator OZh-200; 8 - intermediate vessel PS-50; 9 - compressor AU-50; 10 - oil separator OMM-80; 11 - condenser/capacitor KTG-110; 12 - Dows's-80 compressor; 13 - dehydrator of type OZh-200; 14 - regulating station; 15 - air cooler of box; 16. the cooling-system fan of box.

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At first stage cooling air is produced to 5°C with maintenance by its two compressors 9 type AU-150; at the second step/stage of cooling, the air is led to -40°C. This system is serviced by two compressors of Dows's-80 12 type. The equipment, indicated in the diagram, provides the supply of cold air up to 2 kg/s in flow rate to -40°C at the temperature of surrounding atmospheric air +15°C. If necessary for such type of unit, they can be constructed, also, for other test conditions and different consumption. For larger installations during large heat liberations by brake group the latter can be removed beyond the limits of box. In this case the shaft of engine must be connected with brake with the aid of the connecting shaft, passing through the intermediate wall with stuffing-boxs seal. For engine

testing at elevated temperatures and large air humidity, the box can be constructed according to similar diagram. In this case, the heating of tested engine can be produced by the heating radiators where as heat carrier is utilized hot water or pairs. Heating and air supply for the feeding of engine is realize/accomplished from calorific installations. Air humidity can be regulated by water injection or pair into its system of preheating.

§4. Auxiliary services and the arrangement/permutation of laboratories.

1. Compressor stations.

The gas-dynamic laboratories of the gas turbines of some testing units consume a relatively larger quantity of compressed air. The users of the compressed air are bench stands: turbines, the combustion chambers, blasting of blades, cell/elements of the grates, receiving and outlet branches and other target/purposes.

Basic parameters: pressure of the compressed air and flow rate per second, and also the duration of testing they will be determined by power and construction of turbine, its assemblies and by the

character of the conducted testing. For contemporary gas turbines the pressure of the compressed air after compressor oscillates within limits 4-10 kg/cm^2 and it is above with its consumption from several tenths of kilogram to several kilograms per second. The duration of testing can be also from several minutes to several hours. Thus, even in successive work of the installations, which consume the compressed air, its consumption can reach high values.

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For the satisfaction of these necessities, the supply of laboratory with the compressed air can be provided to one of the following methods:

a) from compressor or group of the industrial compressors, workers in parallel during entire time of testing, with the supply of the compressed air is direct to testing unit;

b) from the compressor of high pressure, working on the charge footlight of the bottles in which is created the reserve of the compressed air under pressure 220 or 350 kg/cm^2. The user the compressed air enters through the reducer, adjusted to the necessary pressure;

c) by the method of air bleed from the compressor of auxiliary gas turbine or from the separate compressor, rotated by electric motor or gas turbine.

In the first case the productivity of compressor will be sufficiently high, since it must be equal to the required consumption of the compressed air. For these purposes most adequate/approaching will be the turbocompressors with drive from electric motor as more compact assemblies. They can be furnished both indoor of laboratory itself and in separate building in the form of independent compressor station. With productivity 3-5 kg/s and above such compressors require the device of basement or arrangement/permutation in the two-story, specially fitted out building.

In the second case the reserve of gas cylinder footlight is determined by the consumption of the compressed air and by the maximum duration of experiment. The productivity of compressor station will depend on the capacitance/capacity of gas cylinder footlight and permissible duration of the supply of the compressed air. The latter will depend on the permissible interruption on the time between two tests. Compressor station can be arrange/located in the common/general/total building of laboratory or in special building. Gas cylinder footlight can be the open type.

2. Auxiliary shops.

The practice of work of the laboratories of engines and gas-dynamic laboratories in question shows that all the testing units and stands are frequently subjected to reconstruction and modernization. Setting and the solution of the problems, connected with the advent and improvement of the constructions of engines, causes the need for frequent conversion or re-planning of the test benches and installations.

Small and routine repair and training/preparation of installations for tests are also labor-consuming works and require daily attention. Eliminating conducting major overhaul and the manufacture of large equipment which are fulfilled by the appropriate shops of plant, all remaining works, as a rule, they are carried out by the forces of laboratory itself. Therefore it must furnish sufficient developed machine shop with a tool making-welding and assembly compartments for the operational execution of all works both on the conversion and on training/preparation of installations and stands for test work. Furthermore, for providing the normal operation of laboratory are necessary other auxiliary services, enumerated in Table 12.

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3. Arrangement/permutation and the planning of laboratories.

Gas-dynamic laboratories or the laboratories of engines can be placed in separate independent housing or together with the experimental station of series production, and also with another pilot plants.

The character of the testing units of these laboratories and their arrangement have much in common with experimental stations. Therefore those who were given in chapter VII of consideration according to artificial satellite arrangement, the selection of conveying devices, the determination of required areas and work force will be completely valid also for the laboratories in question.

Laboratory must have as far as possible the larger perimeter of external walls for providing the arrangement/permutation of installations and compartments, and also for the more convenient arrangement of the sound-deadening devices, supply and

input/introduction of fuel lines. In this case, the gas-bleeding systems to more expedient furnish on the one hand of housing, leaving opposite side for aggregate compartments and the auxiliary services of laboratories.

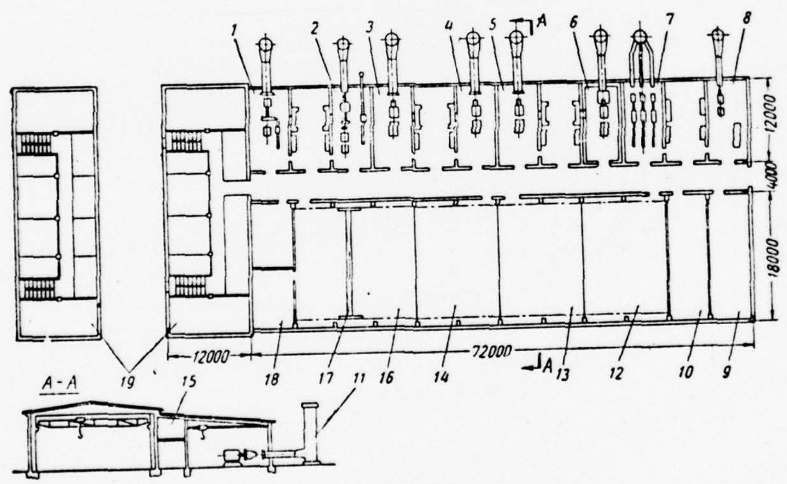

Fig. 46. Diagram of planning of gas-dynamic testing laboratory of gas turbines: 1 - stand of gas turbines; 2 - stand of compressors, blasting of blades, grates it puffed; 3, 4 and 5 - stand of gas turbine engines; 6 - unit for special climatic testings of engines; 7

- stand of combustion chambers; 8 - stand of starters and reducers of engines; 9 - location for testing fuel equipment; 10 - location for testing of oil pumps, filters and another oil equipment; 11 - tubular muffler; 12 - the location of cooling installations and equipment for climatic testings; 13 - shop of laboratory; 14 - dynamoelectric hall; 15 - ventilation location; 16 - Preparatory room; 17 - electric crane-beam; 18 - gasoline flushing room; 19 - everyday and auxiliary-service locations.

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As an example Fig. 46, depicts the planning of gas-dynamic testing laboratory of gas turbines with the arrangement in separate housing. Its building has a form of rectangle with arrangement on its end/face of administrative-everyday locations. The testing units of laboratory are arrange/located along one side of housing, from another side are placed aggregate stands and auxiliary services. The right side of the housing allows for of further expansion without the disturbance/breakdown of the planning of the existing locations of laboratory.

Chapter X.

Special and auxiliary services, devices and systems.

§1. Special services.

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In a number of cases in the conditions of technological process and character of the production of piston engines and gas turbines, experimental stations and laboratories are equipped with special and auxiliary services and devices. Among them from number most frequently encountering in practice they can be:

a). Power supply, that includes generator, battery or rectifying installations for conversion or obtainings of the direct current of

low voltage from 6 to 36 V, designated for the feeding of starters and other electrical or combined starters. They can be the centralized, group or individual. Since the launching/starting of engine occupies short time, in calculations usually is accepted simultaneously the starting/launching only of one unit. In this case, the source power of feeding is selected according to the highest efficiency of user - engine starter. To avoid simultaneous connection/inclusion for the starting/launching of several test benches on power supply, is provided for the blocking. Since starting currents during starting/launching reach very high values, for the purpose of shortening the losses and communications converters are not recommended to relate from the test benches more than on 50 m. Furthermore, one should place them in the isolated/insulated or fenced off from other services location.

b). Oscillographic. For recording and the visual observation of the fast flowing processes, such as vibrations, change in the pressures, temperatures and other values is encountered the need of applying the oscillographs. The latter can be furnished both in the control panels separate testing units and in separate locations for the centralized maintenance of several stands. In the latter case with oscillographic, it is expedient to have a photo-room for the development of films with the recording of oscillograms.

c). Gasoline flushing. In certain cases, especially for large experimental stations or laboratories, appears the need for organization of separate gasoline flushing area.

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It is intended not only for the flushing of parts, assemblies and assemblies during their replacement on engines, and also for the flushing of bench reinforcement and filters. For mechanization of washing works, one should apply jet-edge flushing by means of the forcing of gasoline by the compressed air. For this purpose outside assignment at a distance from wall not less than 6 m into the earth/ground will be sunk 2-4 fuel tanks by the capacitance/capacity of 1.0-2.0 m^3, half from which in turn is either forcing or drainage capacitance/capacities. To avoid fires and explosions, the illumination and electric wiring in gasoline flushing must be explosion-proof.

The suction and exhaust ventilation of washing can be local in the form of on-board suctions from baths or from the cabinets and other shelters of baths, and also general exchange for entire location of washing. In the latter case the multiplicity of the exchange must be is not less than 20-25 exchanges in hour with the excess of a quantity of drawn off air above the inflow.

d). Units for the blowout (cooling) of assemblies. Some types of transport engines require during the bench tests of the forced cooling of some assemblies by means of blowout by their air. Such assemblies, which require air cooling, include the generators and compressors and all other mounted auxiliary mechanisms, which are the affiliation/accessory of engine, and also such assemblies and the parts of engine as turbine casing, the lower part of the crankcase and others. The blowout of the enumerated assemblies and assemblies is determined by the necessary consumption of air which depends on pressure and section/cut of air-supply tube and can be realized from industrial mains of the compressed air or from high-pressure fan.

e). Ventilator systems. With the planning of building and the arrangement/permutation of the equipment of experimental stations and laboratories, one should separate the appropriate areas and place for the arrangement of the supply and exhaust ventilation chambers. During the arrangement/permutation of testing units in common/general/total hall, these chambers are furnished on the pads within building or in the specially diverted locations, which adjoin this hall.

With the arrangement of the test benches in boxes, the

ventilation, heating or sprinkling are necessary only for the period of installation and disassembly of engine from stand. Therefore these systems work periodically, and control by them one should realize/accomplish from the cabin/compartment of control. In the locations of technological equipment of power-supply systems and in the cabin/compartments of control it is necessary to provide for general-exchange suction and exhaust ventilation. The practice of operation of the experimental stations of foremost machine-building plants showed that in the sufficiently well assembled fuel and oil communications and the absence in them of leakages and inflows the multiplicity of the exchange of air in hour within limits of 15-25 completely provides the purity/finish of air in these locations with the content of harmful impurities in air below maximally permissible concentrations.

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In the presence of separate locations for area of technological equipment, power-supply systems, for example, under the cabin/compartment of control or in adjacent with it location, and with the possibility of the temporary stay in it of the service personnel the multiplicity of exchange in these locations can be lowered to 5-10 exchanges in hour. For the purpose of the provision for the necessary soundproofing, one should avoid the packing of air

channels and air ducts between box and cabin/compartment of control. If necessary for the packing of the same, they must be equipped with the sound-deadening devices. In connection with this, and also for imparting of proper form and shaping the cabin/compartment of control ventilation air ducts as far as possible one should provide for in the form of the built-in into structures channels, or in the form of the ducts, hemmed to ceiling overlaps.

§2. Systems of gas extinguishing of fires.

The testing units, arrange/located in the boxes on which during testing of engines, of fuel systems or separate assemblies can occur the fires, it is expedient to equip with system of gas-extinguishing of fires. Especially such systems it is useful to have during testing of experimental-experimental articles when most of all are possible fires. In this case for the preservation/retention/maintaining of experimental model and explanation of the reasons for the emergence of fire, it is necessary to have the reliable high speed fire extinguishing system. Fires on stand usually appear with the finishing of tested engine during boosting or as a result of the burnout of the combustion chamber, disturbance/breakdown of the seal of fuel pipe and its reinforcement, appearance of a leak of

fuel/propellant and its incidence/impingement to the highly heated parts of engine, destruction of flexible hose or Durite connection of fuel line of gas turbines, and also as a result of falling of the burning mixture into carburetor during backfire, as a result of the impoverishment of its and other reasons, which are powerful to be at piston engines.

The principle of work of the system of gas extinguishing of fires consists in the fact that in the case of the emergence of fire the location of testing unit is filled with the gas, inert to burning, i.e., by that not containing free oxygen, in consequence of which the burning of the emergent fire ceases. Such gases include carbonic acid, nitrogen and other inert gases, and also special mixtures, for example mixture 3.5V, and others. The filling of locations with gas must be produced only in the absence in them of people. Therefore these systems are virtually used for the testing units, arrange/located in the separate isolated/insulated boxes. For the more effective quenching of fire, it is necessary to insulate box from report/communication with atmospheric air. Therefore during the emergence of fire, one should close supplying and discharging air and waste gases conduit/manifolds or channels. In this case, their shutter/valves, damper or catches must have the power drives, included from control panel.

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The system of gas extinguishing of fires one should have that which was centralized, common/general/total for all testing units. Of this case it will consist of: a) capacitance/capacities for storage under pressure by compressed mixture or compressed gas for extinguishment of fires;

b) manifold with the close fitting valve, diluted on boxes both the most probable places of origin of fires, and by the conclusion/derivation of the starter of this system into the cabin/compartment of control.

The burning of fire ceases with the filling with gas of the box when gas concentration comprises not less than 40o/o entire volume of air, which is located in the test pit. For the effectiveness of localization of fire, the gas pipe of system, which concludes with several nozzles or injectors, follows as far as possible to feed nearer to stand and engine. After the launching/starting of system into action fire, it ceases during 20-40 s. The positive side of this system is that fact that it does not exert itself harmful effect on part and the construction of tested engine, also, on the equipment of testing unit. Gas cylinder footlight with gas for the quenching of fires must be located in the specially separated single-stage location.

§3. Channelization-drainage systems.

If necessary for jettisoning and possibility of the overflow of water and inflows of the cooling systems or other bench systems for area of stand, it is necessary to have channelization receiving grates (ladders). For providing the drainage of water and maintenance of the purity/finish of sex/floor in area of possible leakages, the sex/floor must slope to the side of ladder. When, in water, harmful toxic or inflammable contaminations are absent, drainage ladders can be connected with drain downpour channelization. If into effluents can fall the residue/remainders (inflows) of fuel/propellant or oil, then drainage conduit/manifold must be laid (outside building) and equipped with special snatcher or the sump of fuel/propellant and oils.

In the presence of the considerable leakages of fuel/propellant and possible emergency overflows of its or technological ejections of fuel/propellant from engine as, for example, when conducting of false starts of some gas turbines, sometimes it is necessary to provide for the system of draining these contaminated fuel it is waste.

In this case in area of the greatest accumulations of such, is waste in the sex/floor of location it is provided for installation of ladder, connected by drain conduit/manifold with the drainage capacitance/capacity, sunk into the earth/ground, outside building. Drainage capacitance/capacity is equipped by scavenge pump with mechanical or hand drive for periodic removal from it fuel it is waste.

Sometimes instead of the channelization ladder is arranged the pan/pallet, arrange/located on the sex/floor or under unit in the zone of the possible ejections of fuel/propellant, which they connect by conduit/manifold with drainage capacitance/capacity.

Chapter XI.

Mechanization and automation of production processes.

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The overall mechanization of production processes at engine-building plants cannot go around experimental stations. Especially this concerns the stations of mass and series production. The analysis of labor intensity on experimental stations shows that in the majority of cases the preparatory and auxiliary activities, produced at units themselves, compose the very considerable expenditures of time, which causes unproductive idle times of the expensive constructions and equipment. In connection with the experimental processes and the research of the methods of an increase in the labor productivity they must be solved in following main directions.

a) Maximum shortening in the time, spent on preparation and finishing works, produced on stand, such as: the delivery/procurement of engine to stand, unit on stand and fastening, the connection of

the feeding communications, measuring systems and control, disassembly after testing and other works, produced in reverse order after engine testing.

b) shortening the time for adjustment-fitting works, produced at unit in the process of testing, because of pre-check and the testing of systems, mounted mechanisms and engine accessories in the process of assembly.

c). Automation of recording, recording and processings of measurements during performance testing and calibration of engine and the application/use of a programmed control during its testing.

The indicated overall mechanization of production processes first of all one should consider as development and the implementation of the measures, directed toward an increase in the coefficient of utilization of testing units. The realization of these measures makes it possible for new experimental stations to reduce the number of requiring testing units, to decrease capital investments and periods of building; for those who exist - to raise labor productivity, to reduce staffs and the operating costs and to raise the quality of engine tests.

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For preparation and finishing work the number of such organizational and technical measures, which raise the effectiveness of testing units, one should relate:

a) the transfer of preparatory works from stand into the hall of training/preparation, which will make it possible to reduce the retention time of engine at testing unit. Outside stand in the zone of training/preparation it is possible to produce testing and visual inspection of engine, taking plug/silencers and plugs, setting up of measuring sensors and similar to them works;

b) the application/use of the engine mount or mobile stand-trucks to which the engine preliminarily is installed in the hall of training/preparation where is produced its brace inspection and measurement by communications with the conclusion/derivation of their ends to special flap. Engine together with the engine mount or on stand-truck is moved to the testing unit where performs only its mating with braking device, but flap with the collector/receptacle of bench inspection and measurement communications;

c) the application/use of the high speed fastenings of engine together with engine block frame or stand-truck on the stand of

testing unit;

d) use of the high speed connections for all feeding and which operate engine conduit/manifolds, monitoring-measuring equipment and devices will make possible for short time to produce the connection of all bench communications directly to engine and its flap.

Unlike the common methods of the transportation of engines on unit, the application/use of mobile stand-trucks or the engine mounts can give a whole number of significant advantages. Especially this is related to large-size heavy engines during their testing in separate boxes. Operations on delivery/procurement and import of such engines into box and reverse/inverse transportation are complex, bulky and labor-consuming. The use of upper lifting-transporting devices for these purposes is hinder/hampered or is excluded due to the impossibility of the necessary packing/seal of large apertures according to the considerations of fire safety and soundproofing. Therefore it is necessary to resort to intermediate, trolley/truck transport with four rearrangements of each engine when conducting of one testing. Furthermore, for the setting of engine to stand and its taking from stand box is necessary to equip with lifting-transporting devices in the form of tap/cranes, jibs, or a monorail with telpher. For these operations it is necessary to lengthen box and to especially increase its height/altitude. Fig. 47, shows the schematic

of this transportation and installation on stand. Application/use of self-propelled stand-trucks or movable engine mounts makes it possible to reduce the time of transportation and to considerably entreat this operation.

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In this case, the engine after fastening to foundation and its connection with brake tests directly on the transported device, without its common rearrangement in box, which makes it possible to considerably reduce the dimensions of boxes along the length and height/altitude and to forego bench lifting-transporting devices.

If necessary for more rigid installation at the testing unit of stand-truck, the latter can have jack type lowering device, which makes it possible to lower the stand-truck to special fastening beams and the farm/trusses of the power frame of foundation. A similar device can be both with mechanical and with hand drive.

Fig. 48, shows the diagram of experimental station with the application/use of self-propelled stand-carts for testing the powerful gas turbines for law courts and gas turboelectric locomotives. The turbine, supplied to experimental station from assembly shop, in the compartment of training/preparation is

remove/taken by tap/crane and is establish/installed on a stand-cart. Here is produced fastening turbine for the stand-cart, its equipment and training/preparation for testing. Turbine, passed testing and locating in box, is rolled from the latter, but not its place is imported new, previously prepared. In box the frame of the stand-cart with the aid of jack device lowers together with engine on the power frame of the foundation of unit and is fastened to the latter with the aid of the high speed fastenings. Then is produced shaft coupling of turbine with the flexible coupling clutch of the shaft of braking device and the connection of engine to the bench communications of testing unit. Thus, each box has two shuttle of stand-cart on which alternately they are installed, test and are dismantled engines. Less overall and not heavy engines can be transported into box on stand-supports with the aid of electric car with the lifting stage.

The organization of engine tests according to this diagram considerably raises the productivity of installations. Besides that which was given, can be used other diagrams, for example, the method of the delivery/procurement of engines into the box with the aid of transporter truck and other methods.

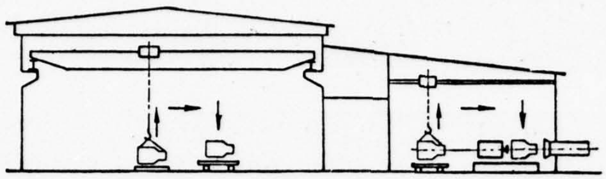

Fig. 47. Schematic of common transportation of engines with arrangement of testing units in separate boxes.

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A reduction in the expenditures of the time, expended to regulating-setup works, produced on stand in the process of engine testing, is also the large reserve of an increase in the throughput capacity of testing units. Reduction/descent in the labor consumption of these works and shortening the encountered flaw/defects in engine, eliminated in the process of its testing, can be reached by the application/use of advanced technology of assembly. Such a technology must provide for conducting preliminary tests and regulating works on separate assemblies, assemblies and systems and on engine as a whole, in the process of their assembly or after it. Such works include the testing and control of all pumps, pumps, including of the fuel pumps, injectors and other hung up for engine mechanisms and assemblies. Furthermore, by assembly must be produced testing the separate

systems of mixture distribution, ignition, lubrication, cooling and others, including testing packing/seals, leakage test, and also testing and the control of the interlock systems and automation. All these operations must be produced under conditions, approximated to full-scale, in the part of the temperature conditions, pressure, speed and other test conditions.

During testing of many types of engines, it is necessary to simultaneously determine the different characteristics and the parameters of engine, in the different modes of its operation and frequently on numerous points.

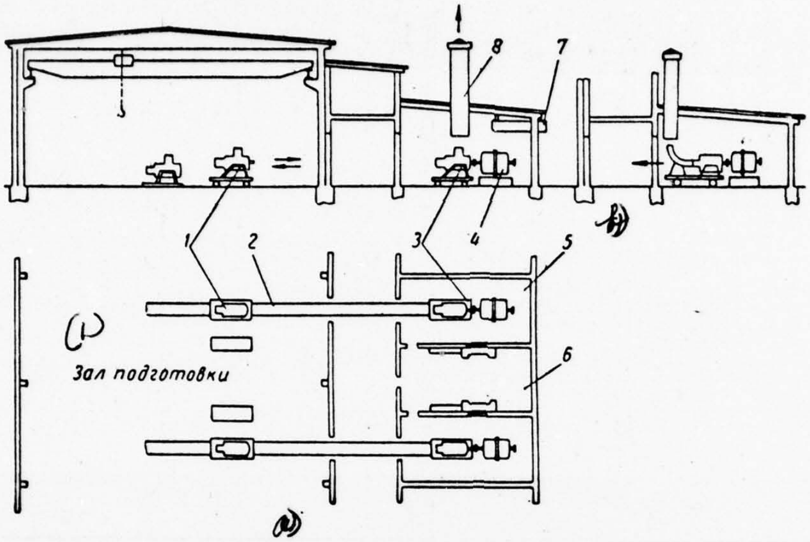

Fig. 48. Diagram of experimental station with movable stand-cart: a) for engines with vertical gas outlet; 1 - engine, establish/installed on stand-cat; 2 - rail track; 3 - engine on stand-cart connected to brake; 4 - braking device; 5 - box for testing; 6 - cabin/compartment of control; 7 - horizontal air-inlet silencer; 8 - vertical tubular gas-bleeding silencer; b) for engines with horizontal gas line. Stand-cart with the swinging elbow for the jet direction of waste gases.

Key: (1). Hall of training/preparation.

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It is this involved the measurement of power, speed, temperature and

air pressure, and also the consumption of fuel/propellant, oil, of cooling water and other values. With the visual method of reading of instruments and even during the use of chart recorders on recording and processing of these readings usually is spent much time and fuel, but taking these characteristics not always does bear objective character. Therefore mechanization of these works is the completely contemporary and necessary task.

Application/use in this field of the specialized computer makes it possible to utilize it in two directions;

to automate recording, recording and the mathematical processing of all conducted measurements during performance testing and calibration of engine with obtaining of printed record sheet;

to introduce automatic control of the process of testing according to predetermined program.

For the indicated target/purposes are most appropriate the specialized, managers, who record, the computers (URVM), made by Soviet industry. Such machines depending on type and the construction can on experimenter's command/crew for one second record from several dozens to several hundreds of different values and readings. Mathematical processing, including the determination of the specific

consumption of fuel/propellant and oil, the computation of power and its bringing to standard conditions and other similar to them calculations, and also printing on the paper tape of the results of measurements and computations electronic computer are made for a few minutes. URVM can conduct control of the process of engine testing on to predetermined program. In the case of the deviations of the values of some parameters of tested engine from permissible, according to the established/installed technical specifications of URVM it overhangs the electrical signals to actuating mechanisms for the regulating of the assigned magnitudes or for the cessation of engine testing.

URVM is the digital computer, which allow/assumes known flexibility in the relation to the rearrangement both the program of control and the programs of calculating operations. One Such machine, establish/installed in area of testing units, can service several stands.

The primary information about the values of the quantities of the measured parameters of tested engine (pressure, temperature, the rotational speed, fluid flow rate, etc.) enters URVM in the form of the electrical signals, sent by the special measuring sensors, arrange/located during engine or test equipment. As sensors for the measurement of different temperatures, can be used the produced by

industry series specimen/samples of the resistance thermometers and thermocouple, but for the measurement of pressures - extensometric pressure sensors of special manufacture.

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The measurement of the torsional moment can be produced either with the aid of momentum/impulse/pulses from strain gauge, or with the aid of the momentum/impulse/pulses, sent from weight gage instrument. The latter can be reached by the unit of photoresistance on the scale of the weights which will overhang momentum/impulse/pulses with blackout by their arrow/pointer with its displacement. According to the same principles can be measured the consumption of fuel/propellant and oil from weight flow meters.

During automatic control of the process of engine, testing change in the mode/conditions and the control of its work is realize/accomplished according to the test programs and blockings, placed on punch card into the assembly of the control of URVM. The control unit continuously obtains the signals from measuring sensors and it compares these signals with the allowed values of the parameters of engine. In the case of the nonconformity of these parameters, the control unit overhangs the electrical signals to actuating mechanisms for the control of the operation, and with the

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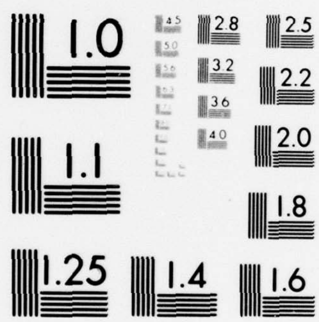

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

impossibility of obtaining the necessary values, is produced its stop. According to test program, the control unit overhangs also the electrical signals to the actuating mechanisms, matched on time with the graph of testing, for a change in engine power rating and its translation/conversion into the following stage of tests. The entering from assembly controls the actuating mechanisms the signals are converted into the mechanical displacements of corresponding engine controls.

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APPENDICES.

Appendix 1.

Maximum permissible concentrations of poison gases and vapors of some substances in air of working locations.

(Extract from appendix 3 to the sanitary norms of design N 101-54).

(1) Наименование вещества	(2) Величины предельно допустимых концентраций в мг/л	(3) Наименование вещества	(4) Величины предельно допустимых концентраций в мг/л
(5) Акролеин	0,002	(6) Окись углерода	0,03
(7) Аммиак	0,02	(8) Ртуть металлическая . .	0,00001
(9) Ацетон	0,2	(10) Сернистый газ	0,02
(11) Бензин	0,3	(12) Сероводород	0,01
(13) Бензол	0,05	(14) Сероуглерод	0,01
(15) Керосин	0,3	(16) Спирт метиловый	0,05
(17) Лигроин	0,3	(18) Спирт этиловый	1,0
(19) Минеральное масло в пересчете на углерод . .	0,3	(20) Уайт-спирит	0,3
		(21) Хлор	0,001

Key: (1) Designation of substance. (2) Values of the maximum permissible concentrations in mg/l. (3) Designation of substance. (4) Values of the maximum permissible concentrations in mg/l. (5)

Acrolein. (6). Carbon monoxide. (7). Ammonia. (8). Mercury is metallic. (9). Acetone. (10). Sulfur dioxide. (11). Gasoline. (12). Hydrogen sulfide. (13). Benzene. (14). Carbon disulfide. (15). Kerosene. (16). Alcohol is methyl. (17). Ligroin. (18). Alcohol is ethyl. (19). Mineral oil in conversion for carbon. (20). Mineral spirits. (21). Chlorine.

Notes: 1. With the temporary stay of workers in production locations, are allow/assumed the digressions from the indicated values by authorization of Gossaninspektsiya USSR.

2. In work in the atmosphere, which contains carbon monoxide, by duration not more than 1 h maximum permissible concentration of carbon monoxide can be raised to 0.05 mg/ℓ; in work it is not more than 30 min - to 0.1 mg/ℓ; in 15 min - to 0.2 mg/ℓ. Repeated works under conditions of the industrial content of carbon monoxide in air of working zone can be produced with interruption not less than for 2 h.

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Appendix 2.

TEMPORARY NORMS OF ACCEPTABLE NOISE LEVELS IN PRODUCTION.

Extraction from "time/temporary sanitary norms and the rules on the limitation of noise in production", affirmed by the main state sanitary inspector of the USSR on 9 February 1956 No 205-56.

TEMPORARY NORMS FOR ACCEPTABLE NOISE LEVELS IN PRODUCTION.

Designation/purpose and the field of application.

1. Present norms establish/install values of tolerance levels and noise spectra of work areas in production and basic requirements, directed toward prevention/warning of occupational diseases of persons, working in situation of noises.

Note. The values of permissible noise levels, adjustable by present norms, are real with the normal duration of workday.

2. Norms are spread for industrial enterprises,

scientific-research institutes of laboratory and experimental objectives in which is establish/installed equipment, which creates noise.

Acceptable noise levels in production.

3. All noises depending on their frequency composition (spectrum) are divided into three classes: I - low-frequency, II - middle frequency and III - high-frequency noises.

For each of these classes, are established acceptable noise levels in decibels.

Acceptable noise levels in production for the noises of different classes.

(1) Класс и характеристика шумов	(2) Допустимый уровень в *дб*
(3) *Класс I.* Низкочастотные шумы (шумы тихоходных агрегатов неударного действия, шумы, проникающие сквозь звукоизолирующие преграды — стены, перекрытия, кожухи). (4) Наибольшие уровни в спектре расположены ниже частоты 300 *гц*, выше которой уровни понижаются (не менее чем на 5 *дб* на октаву)	90—100
(5) *Класс II.* Среднечастотные шумы (шумы большинства машин, станков и агрегатов неударного действия). (6) Наибольшие уровни в спектре расположены ниже частоты 800 *гц*, выше которой уровни понижаются (не менее чем на 5 *дб* на октаву)	85—90
(6) *Класс III.* Высокочастотные шумы (звенящие, шипящие и свистящие шумы, характерные для агрегатов ударного действия, потоков воздуха и газа, агрегатов, действующих с большими скоростями) — наибольшие уровни в спектре расположены выше частоты 800 *гц*	75—85

Key: (1). Class and the characteristic of noises. (2). Tolerance level in db. (3). Class I. Low-frequency noises (noises of the slow assemblies of unstressed action, the noises, which penetrate through sound barriers - wall, overlaps, jackets). (4). The greatest levels in the spectrum are arrange/located below the frequency of 300 Hz, higher than which levels are depressed (not less than to 5 db to octave). (5). Class II. Middle frequency noises (noises of the majority of machines, machine tools and assemblies of the unstressed

action). (5a). The greatest levels in the spectrum are arrange/located below the frequency 800 Hz higher than which levels are depressed (not less than to 5 db to octave). (6). Class III. High-frequency noises (ringing, sibilant and whistling noises, characteristic for the assemblies of percussion, the air flows and gas, assemblies, which effect at high speeds) - the greatest levels in the spectrum are located higher than the frequency 800 Hz.

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4. Necessary additional condition to indicated tolerance levels and noise spectra is intelligibility of speech, which must be satisfactory under conditions of noises of all three classes, namely: speech, pronounced by voice of normal volume, must be well clear at a distance 1.5 m of speaker.

5. In quiet production rooms arrange/located on territory of plant, such as design bureaus, office and administrative locations, in private and windows the loudness level of the noise, which penetrates into these locations from other production locations, must not exceed 50 backgrounds, without depending on the frequency composition of noise. The condition, presented in p. 4, to these locations is not related.

6. Noise levels are measured by objective audio-noise meter, and frequency spectra - by audio-noise meter with fitted out to it band-pass filter or analyzer.

Noise level on edge of sanitary-shielding zone.

According to norms N 101-54 and the indications of Gossaninspektsiya, the noise level in area of residential sections is settlement, that are located close to the arrangement of experimental stations and laboratories, must not exceed 70 db. Zone of protection, i.e., distance from experimental station or laboratory to habitable houses, it should be had as a radius of 300 m.

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Appendix 3.

Categories of the locations of experimental stations and laboratories according to their degree of fire- and explosiveness hazard.

(1) Наименование помещений и служб	(2) Категория пожаро- и взрывоопасности	(3) Класс по правилам устройства электрооборудования
(4) Зал испытательных установок или помещения боксов для отдельных испытательных установок . .	Г	П-1
(5) Кабины управления испытательных установок . .	Г	П-1
(6) Помещения под кабинами управления или помещения технологического оборудования систем питания топливом, маслом	Г	В-1б
(7) Подвалы, проходные тоннели или штольни для коммуникаций, располагаемые в районе испытательных установок и стендов	Б	В-1б
(8) Чердачные помещения над боксами и кабинами управления	Г	П-1
(9) Вентиляционные камеры, располагаемые над проездами и коридорами между боксами, над боксами или над кабинами управления	Г	П-1
(10) Зал подготовки двигателей и агрегатов, препараторские, помещения для устранения дефектов в двигателях и агрегатах	Г	П-1
(11) Помещения установок для испытания топливной аппаратуры и агрегатов с применением бензина и керосина	А	В-1а
(12) Помещения бензопромывочной	А	В-1а
(13) Помещения для цеховых кладовых, хранения и раздачи масел (маслокомнаты, маслораздаточные и т. д.)	В	П-1

Key: (1). Designation of locations and services. (2). Category of fire-hazard and explosiveness. (3). Class according to the rules of the device of electrical equipment. (4). Hall of testing units or

location of boxes for separate testing units. (5). Cabin/compartments of the control of testing units. (6). Locations under the cabin/compartments of control or locations of the technological equipment of power-supply systems by fuel/propellant, oil. (7). Basements, passage tunnels or the galleries for communications, arrange/located in area of testing units and stands. (8). Garret locations above boxes and cabin/compartments of control. (9). Ventilation chambers, arrange/located above passages and the corridors between boxes, above boxes or above the cabin/compartments of control. (10). Hall of training/preparation of engines and assemblies, preparatory, location for the elimination of flaw/defects in engines and assemblies. (11). Locations of stands of fuel equipment and assemblies with the application/use of gasoline and kerosene. (12). Locations of gasoline flushing area. (13). Locations for shop storerooms, storage and distribution of oils (Oil rooms, oil distributors, and so forth).

Notes: 1. Categories fire- and to the explosiveness of locations enumerated above are determined in connection with the "fire-fighting norms of the construction design of industrial enterprises" N 102-54 committee in the matters of building of USSR, republished with changes and introduced into action with 1/VIII 1959.

2. Classes on electrical equipment are determined in connection with "rules of device of electrical equipment", issued by the Ministry of power stations.

3. Degree fire- and explosiveness and class of electrical equipment of locations, which did not enter this enumeration, are determined in each individual case from norms indicated above and rules.

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Appendix 4.

Flash point, self-ignition, and explosiveness of mixtures of combustible vapors and gases with air.

(1) Наименование веществ	(2) Температура вспышки	(3) Температура самовоспламенения	(4) Пределы взрываемости в смеси с воздухом в процентах по объему	
			(5) Нижний	(6) Верхний
(7) Ацетон	—17	570	2,9	13,0
(8) Ацетилен	—	480	2,6	20,0
(9) Бензины	(11) От —50 до +30	415—530	1,0	6,0
(10) Бензол	От —15 до +10	580—653	1,5	9,5
(12) Керосин тракторный и осветительный	28	380—425	1,4	7,5
(13) Лигроин	8	415	1,4	6,0
(14) Моторные масла	195—205	300—380	—	—
(15) Окись углерода	—	651	12,8	75,0
(16) Светильный газ	—	600	8,0	24,5
(17) Этиловый спирт	9—32	510—568	3,5	18,0

Key: (1). Designation of substances. (2). Flash point. (3). Self-ignition temperature. (4). Limits of explodability in mixture with air in percentages by volume. (5). Lower. (6). Upper. (7). Acetone. (8). Acetylene. (9). Gasoline. (10). Benzene. (11). From ... to .... (12). Kerosene tractor and illuminating. (13). Ligroin. (14). Motor oil. (15). Carbon monoxide. (16). Illuminating gas. (17). Ethyl alcohol.

Notes: 1. Flash point he is called the lowest temperature at

which the pairs of inflammable liquid with air form the mixture, which gives flash/burst with the presentation of the free flame. Flash point is one of the important exponents the fire hazard of liquid.

2. Self-ignition temperature - this is that temperature to which must be evenly heated combustible mixture with air, so that it would be fired without introduction into it of free flame. Self-ignition temperature characterizes the degree of the fire hazard of different substances. (P. T. Bezuglov, reference table of inflammable substances - Gostoptekhizdat, 1948).

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